REDESIGN OF THE DRBC/NPS SCENIC RIVERS MONITORING PROGRAM

REPORT NO. 18 DRBC/NPS COOPERATIVE MONITORING PROGRAM

DELAWARE RIVER BASIN COMMISSION

DELAWARE WATER GAP NATIONAL RECREATION AREA

UPPER DELAWARE SCENIC AND RECREATIONAL RIVER

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I. EXECUTIVE SUMMARY

I.A. INTRODUCTION

In 1993, the Delaware River Basin Commission/National Park Service (DRBC/NPS) Scenic Rivers Monitoring Program completed its tenth year of operation. The program collects water quality information along a 120 mile reach of the Delaware River (Figure 1). This segment of the Delaware River contains two components of the National Wild and Scenic Rivers System and numerous high quality tributaries that drain portions of three states.

Part II of this report records the history of the 1984-93 program including its rationale and evolution and to present the rationale and design considerations for a new Scenic Rivers Monitoring Program. Various sections of the report describe how the program was redesigned. Recommendations for new monitoring approaches, special studies, program staff reorganization, potential interagency agreements, and operating procedures are presented. It is envisioned that the redesigned monitoring program will likely evolve as it is implemented.

The redesigned program's major recommendations are presented below.

I.B. MONITORING PROGRAM REDESIGN SUMMARY

PROGRAM GOALS (Part III)

- Assess status of "existing water quality as to whether it is "measurably changing" or not;
- Provide an Ecosystem Monitoring Strategy; and,
- Provide Scientific and Technical Input to Management Decisions.

RECOMMENDED BASELINE MONITORING ELEMENT (Part IV)

- **Frequency:** Baseline Monitoring Locations to be monitored monthly unless ice or safety considerations prevent sample collections.
- **Parameters:** Flow; air temperature; water temperature; conductivity; dissolved oxygen; pH; turbidity; ortho-phosphate; nitrite+nitrate; fecal coliform (other parameters to be added as resources permit in the following order of priority; total phosphorus, ammonia+ammonium, total Kjeldahl nitrogen, total dissolved solids, total suspended solids, and E. coli).
- **UDSRR River Locations:** Lordville Bridge; Callicoon Bridge; Callicoon Access; Cochecton Bridge; Tenmile Access Area (or Narrowsburg Bridge); Barryville bridge; Pond Eddy Bridge; and Port Jervis (Route 209 Bridge).

- **UDSRR Tributaries:** West Branch; East Branch; Equinunk Creek; Little Equinunk Creek; Callicoon Creek; Calkins Creek; Tenmile River; Masthope Creek; Lackawaxen River; Beaver Brook; Halfway Brook; Shohola Creek; Mongaup River; and Shinglekill.

- **DWGNRA River Locations:** Port Jervis; Northern DWGNRA Boundary; Milford; Dingmans Access; Bushkill Access; Smithfield Access; and Delaware Water Gap at Arrow Island.

- **DWGNRA Tributaries:** Neversink River; Vandermark Creek; Shimers Brook; Sawkill Creek; Raymondskill Creek; Bushkill Creek; Little Bushkill; Flatbrook; Little Flatbrook; Van Campens Brook; Shawnee Creek; Brodhead Creek; and Cherry Creek.

RECOMMENDED ECOSYSTEM MONITORING ELEMENT (Part V)

- **Delaware River (UDSRR) Pools and Runs:** Vicinity of Buckingham Access Area and Vicinity of Matamoras Access Area.

- **Delaware River (DWGNRA) Pools and Runs:** Northern Milford Area and Vicinity of Bushkill Access Area.

- **Physical Parameters:** Channel and transect depth; bottom substrate; water clarity; velocity; width; riparian zone; and others.

- **Biological Parameters:** Macrophytes; periphyton; macroinvertebrates including mussels; plankton; vertebrates; riparian vegetation; and others.

- **UDSRR and DWGNRA Tributaries:** Macroinvertebrates with habitat assessment

- **Chemical Characteristics:** As per Baseline Monitoring Element.

SUGGESTED SPECIAL STUDIES (Part VI)

- Pollution Problem Surveys (lower West Branch, Callicoon Creek watershed, Delaware River from Port Jervis to Northern DWGNRA Boundary, Cherry Creek watershed, Neversink River watershed, Lackawaxen River watershed, Vandermark Creek watershed, Flatbrook watershed, and Shawnee Creek watershed)

- Boundary Control Points

- Priority Watersheds

- Electronic/Automated Monitoring for Water Quality and Flow

- Low Altitude Remote Sensing

- Time of Travel and Mixing Zones
- Sediment Toxics
- National Park Service Activities including Agricultural Herbicides
- Ground Water
- Delaware River Interagency Water Quality and Biological Survey

OPERATING PROCEDURES (Part VII)

- Proposed Staffing
- Proposed Relationships of Program Partners
- Proposed Analytical Procedures
- Proposed Data Management
- Proposed Quality Control
- Proposed Reporting Procedures
- Proposed Interagency Relationships

MAJOR IMPLEMENTATION STEPS IN 1994 AND 1995

- Secure sufficient **professional staff** at each participating agency - completed 1994
- Implement **Baseline Monitoring** Element on trial basis - completed 1994
- Select and Conduct reconnaissance survey of **Ecosystem Monitoring** study areas - completed 1994
- Conduct special study (low altitude, remote sensing) - completed 1994
- Finalize Scenic Rivers Monitoring Program redesign report - early 1995
- Execute five year **Interagency Agreement** between Delaware River Basin Commission and two National Park Service units (UDSRR and DWGNRA) for participation in the Scenic Rivers Monitoring Program - Early 1995
- Implement Permanent **Baseline Monitoring** Element - 1995
- Implement **Ecosystem Monitoring** Element - 1995

II: HISTORY OF DWGNRA/UDSRR WATER QUALITY MONITORING

II.A PRE-1994 MONITORING

Monitoring activities have been conducted in what is now the Delaware Water Gap National Recreation Area (DWGNRA) and the Upper Delaware Scenic and Recreational River (UDSRR) since the 1920's (Figure 1). These early water quality monitoring efforts were focused on the use of the Delaware River for potable water supply. The various studies determined that the river was a suitable raw water source. As part of a larger process, these early studies culminated in the authorization of the Tocks Island Reservoir Project in 1961 and the establishment of the DWGNRA in 1965.

Monitoring by state health, environmental and fisheries agencies (New Jersey, New York, and Pennsylvania) have a long history as well. For example, water quality data contained in computer data management systems extend back to the 1960's while earlier data can be found in published reports and elsewhere. Data records developed by the U.S. Geological Survey extend back to the turn of the century for flow. A special study conducted by Pennsylvania and New Jersey in 1974 (Brezina et al., 1974), however, was the only systematic study of water quality and aquatic biology done on a multi-state, regional basis until the current DRBC/NPS program.

In spite of the amount of environmental data collected in the region over the years by various entities, routine data collection efforts, other than the DRBC/NPS effort, have been generally limited spatially and temporally with a few sampling locations receiving the bulk of monitoring resources. The lack of comprehensive state monitoring is due to resource limitations and the lower priority ranking of the upper Delaware River region in comparison to the large urban pollution problems found elsewhere in each state.

Extensive statistical analyses of the three state and U.S. Geological Survey databases were conducted by the DRBC/NPS Special Protection Waters program in the 1988-1991 period and was used, along with DRBC/NPS data, to develop water quality criteria that were adopted by DRBC in 1992. The document titled <u>Water Resources Management Plan and Environmental Assessment, Delaware Water Gap National Recreation Area, March 1990 Working Draft</u> (Table C-1 of Appendix C in DWGNRA and DRBC, 1990) presents a summary of this long-term data record for the Port Jervis to Delaware Water Gap reach of the river. The long-term data record for the UDSRR is available by computer diskette.

II.B MONITORING PROGRAMS OPERATING IN 1994

There are currently at least 18 water quality monitoring programs operating in the watershed draining to the downstream boundary of the Delaware Water Gap National Recreation Area (i.e., the scenic rivers region). These vary in size and sophistication. Programs are operated by the U.S. Geological Survey (USGS), the three state environmental agencies, watershed associations, county organizations, environmental groups, sport fishing organizations, the City of New York, DRBC and the NPS.

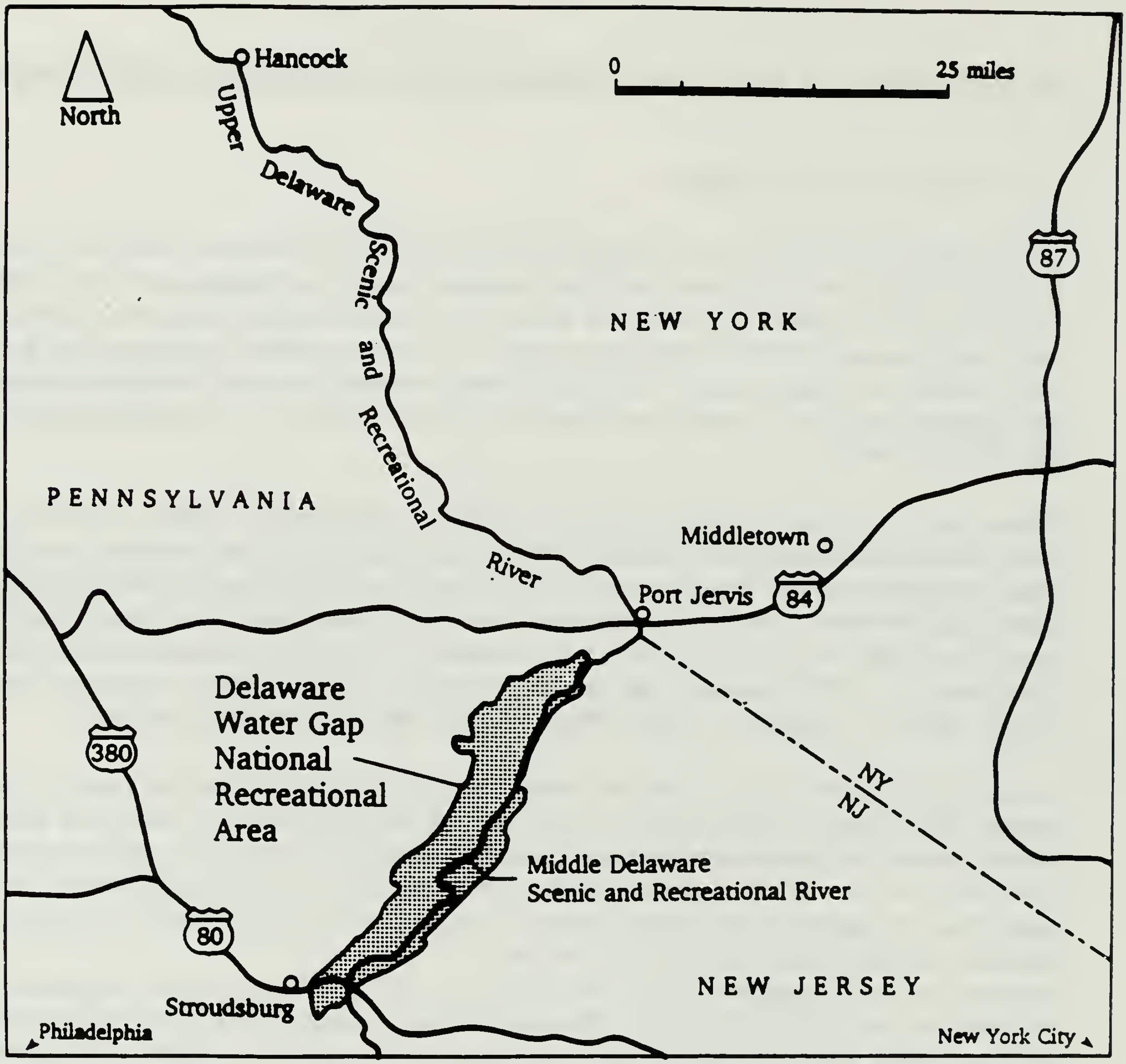

Figure 1: Location of the Scenic Rivers Area

On April 21, 1994 the Commission and the National Park Service hosted a monitoring conference attended by most of the organizations conducting water quality monitoring in the region. Summaries of the various monitoring programs are contained in Proceedings of the Upper Delaware Water Quality and Biological Monitoring Conference, Report No. 17 of the DRBC/NPS Cooperative Monitoring Program (1994).

II.C THE DRBC/NPS SCENIC RIVERS MONITORING PROGRAM

II.C.1 Evolution of the DRBC/NPS Program

The DRBC/NPS Scenic Rivers Monitoring Program (SRMP) evolved from DRBC's Upper Delaware Summer Limnological Program (UDSLP). This program originated in the late 1960's as one part of a two-part study of the potential aquatic life impacts of Tocks Island Reservoir-related pumped storage operations. The limnological study examined fish spawning activity in the DWGNRA along with water chemistry and other habitat considerations (Baren, 1971). Despite the demise of the Tocks Island Reservoir Project in 1975, the Upper Delaware Summer Limnological Program continued through 1978.

In 1979, DRBC staff evaluated the quality and purpose of its Upper Delaware River Summer Limnological Program. Staff determined that the program had an unacceptable back-log of unanalyzed biological samples, an unacceptable level of data analyses and interpretation, no formal or informal reporting procedures, questionable quality control, unstable funding, and, without the Tocks Island Reservoir, no valid purpose. The program needed to be extensively revamped or abandoned.

Concurrently, however, the establishment of the Upper and Middle Delaware scenic rivers in 1978, the re-orientation of the DWGNRA from reservoir-based recreation to river-based recreation, and the rapid increase in river recreation created a need for water quality data - especially when the paucity of monitoring by other agencies was considered. The UDSLP program was, therefore, overhauled and focused on collecting water quality data needed by the National Park Service (NPS), the Commission and others involved in planning activities related to the two national scenic rivers and DWGNRA. Steps were taken to increase quality control and to expand the program while simultaneously winding up the previous program by eliminating the backlog of unanalyzed data. Two reports were eventually published that presented the results of the pre-1979 sampling efforts (DRBC, 1980; Rockel and Rose, 1982).

The DWGNRA, by this time, was concerned about the sanitary quality of its bathing beaches and had contracted with U.S. EPA Region II to conduct a study of fecal bacterial levels in the recreation area (U.S. EPA, 1978). This study, conducted in 1978, recommended a sampling program for the recreation area that was partially implemented. The new NPS beach monitoring program and the revamped DRBC program, therefore, began coordinating their respective activities and instituting mutual quality control protocols. Increasingly, DRBC staff also began using the NPS beach monitoring data to augment their own data and, in 1981 and 1982, the DRBC UDSLP conducted special water quality surveys of the Upper Delaware Scenic and Recreation River and the Delaware Water Gap National Recreation Area, respectively to provide

information needed to address water pollution concerns being raised during the two NPS management planning processes (Albert, 1981; Albert, 1983).

As the result of these initial efforts to coordinate individual monitoring programs, DRBC and DWGNRA staff in 1983 decided to expand their relationship. A small scale study of the impacts of a DWGNRA campground was, therefore, planned and conducted cooperatively by the two agencies to test potential working relationships. As the result of this initial interagency collaboration, a proposed DWGNRA-wide water quality program was designed by DRBC and recommended for joint implementation on a trial basis (Albert, 1984). The pilot program was carried out in 1984.

The 1984 DWGNRA pilot program was a full-scale, interagency effort that integrated agency staffs and functions in accordance with the proposed program design. Due to the combined efforts, overall data collection expanded significantly. Following the completion of the 1984 monitoring activities, the program was thoroughly evaluated. The analyses of the program, its results, and the level of interagency cooperation indicated that the trial monitoring program had exceeded the expectations of both agencies (Albert, 1985; Albert and Karish, 1986). In the following year, the Upper Delaware Scenic and Recreational River joined the program and it was made permanent[1].

To define the status of water quality, the DRBC/NPS routine sampling program has measured air and water temperature, dissolved oxygen, fecal bacteria, conductivity, and pH for the past ten years, augmented with fecal strep analyses, macroinvertebrate collections and total phosphorus and nitrate screening. From 1990 to 1993, special NPS funding supported additional analyses which were performed by a contract laboratory, including ammonia+ammonium, nitrite+nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, ortho-phosphate, and 5-day Biochemical Oxygen Demand (BOD). Total dissolved solids (TDS) and total suspended solids (TSS) were measured from 1992 to 1993. These data were collected on a schedule designed to capture both high and base flow conditions.

Although the baseline water quality monitoring program has proven extremely successful and has been expanded over the ten years of the DRBC/NPS Scenic Rivers Monitoring Program, the major growth in program sophistication and resource expenditure has been in the program's special study component. Although the original program design envisioned only small-scale research (e.g., macroinvertebrate sampling techniques, local pollution surveys, aquatic plant surveys, etc.), the need for information has led to several advanced state-of-the-art studies. These have included:

- 1987 (scenic rivers-wide), 1988 (follow up-UDSRR) and 1991 (site-specific-UDSRR) surveys of sediment toxics including the development of sampling protocols;

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[1] The name "Upper Delaware Summer Limnological Program" was retained for the joint DRBC and NPS program until officially changed to the "Scenic Rivers Monitoring Program" after the 1988 sampling season. The name "Scenic Rivers Water Quality Monitoring Program" has also been used in the past and is synonymous with the latter title. Reports of the program also carry the title DRBC/NPS Cooperative Monitoring Program which is used for the report numbering system only.

- 1988 to 1993 collection of nutrient, biochemical oxygen demand, tributary flow, aquatic plant biomass, and other data for criteria development;

- 1988 to 1993 collection of calibration and verification data for the development of Delaware River water quality and toxic spill models (now under development);

- 1988 (two-DWGNRA) and 1990 (UDSRR) diel studies of dissolved oxygen, temperature, pH, and fecal bacterial characteristics, the former including primary productivity studies;

- Development of water quality and biological definitions of existing water quality;

- the multi-phased (low-flow, high-flow, and reservoir surge wave) time of travel study of 1991 which was the largest single field study ever conducted on the Delaware River; and,

- a 1993 evaluation of electronic automatic sampling equipment for watershed baseline and non-point source data collection.

The increase in the number and sophistication of special studies conducted by the DRBC/NPS Scenic Rivers Monitoring Program is largely due to the initiation of the Scenic Rivers Water Quality Planning Program in 1988. This program was initiated by DRBC, DWGNRA and the NPS Water Resources Division in response to the rapid growth and development that was occurring in the watersheds surrounding the DWGNRA. The growth and the projected increases in both point and non-point sources threatened the water quality, aquatic resources, and other park values of DWGNRA because the water quality criteria protecting the Middle Delaware Scenic and Recreational River was, at that time, significantly lower than the high level of water quality documented by the Scenic Rivers Monitoring Program.

Although initially oriented to DWGNRA, the planning program was expanded in 1990 to include the UDSRR although without UDSRR-NPS participation (due to the unique role of the NPS in the UDSRR). After extensive technical and policy analyses, public participation, numerous meetings and a public hearing process, the DRBC adopted Special Protection Waters regulations on December 9, 1992. The non-point source control provisions of the Special Protection Waters regulations were adopted on February 23, 1994.

The growth in the special study element of the DRBC/NPS Scenic Rivers Monitoring Program is directly related to the Special Protection Waters program. Special studies conducted in the 1988 to 1993 period have been oriented to either (1) the development of data in support of regulation/water quality criteria development, or (2) development of management tools for the post-adoption period. Examples of the former include the various diurnal (24-hour) studies and nutrient studies while examples of the latter include the various model development activities and the evaluation of non-point source monitoring equipment.

Reports derived from the DRBC/NPS water quality monitoring and planning activities are presented in Appendix A. Overviews are presented in Albert, 1986; Albert and Johnson, 1988; and Johnson and Albert, 1993 with a detailed summary presented in <u>Proceedings of the Upper Delaware Water Quality and Biological Monitoring Conference, Report No. 17 of the DRBC/NPS Cooperative Monitoring Program (1994)</u>. Figures 2 and 3 present annual tabulations of program

effort as measured by station-visits and expenditures, respectively. In its ten year history, the program has:

- Made 6300 station-visits;
- Collected over 30,000 data from over 73 river sites and 99 tributary sites;
- Completed about two dozen special studies; and,
- Published 18 reports and 4 papers.

II.C.2 Original Design Considerations

Three objectives of the DRBC/NPS monitoring program, outlined in the original design document, have been used throughout the ten year history of the program. These objectives were:

- to determine on a continuing basis, the status of water quality;
- to determine causes of water quality degradation and improvements when observed; and,
- to provide input for decisions concerning the management of the Delaware River and its tributaries in the Delaware Water Gap National Recreation Area and the Upper Delaware Scenic and Recreational River corridor.

The overall thrust of the program was to conduct no unnecessary sampling at any one site, thereby decreasing the amount of time spent per sampling site. This philosophy realized three advantages:

- Sampling is extensive rather than intensive, covering, as many Delaware River locations and tributaries as possible. A water quality screening approach is employed to maximize available resources for baseline monitoring.
- Sampling is as frequent as possible (biweekly for many locations) in order to capture the natural and anthropogenic changes that can occur rapidly over time (i.e., the program was designed to "fingerprint" water quality in order that variations could be quickly ascertained).
- Data turnaround is rapid (immediate for some parameters) so that the program can respond quickly to pollution problems, if found, that potentially threaten recreational uses and recreationists.

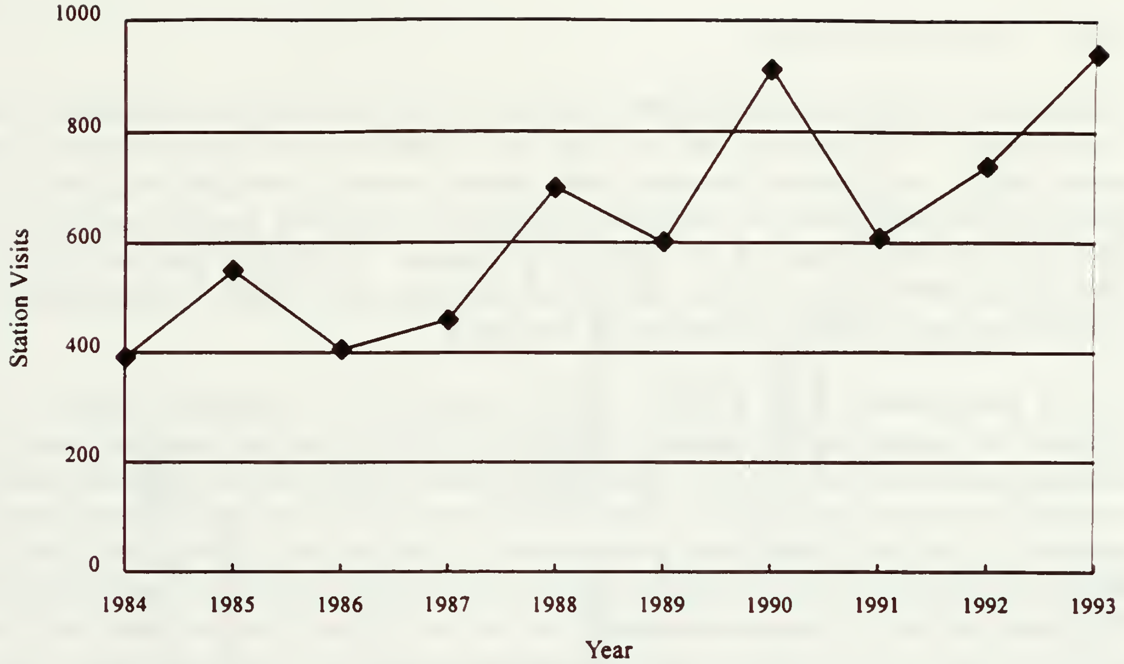


Figure 2: DRBC/NPS annual station visits made by Scenic Rivers Monitoring Program

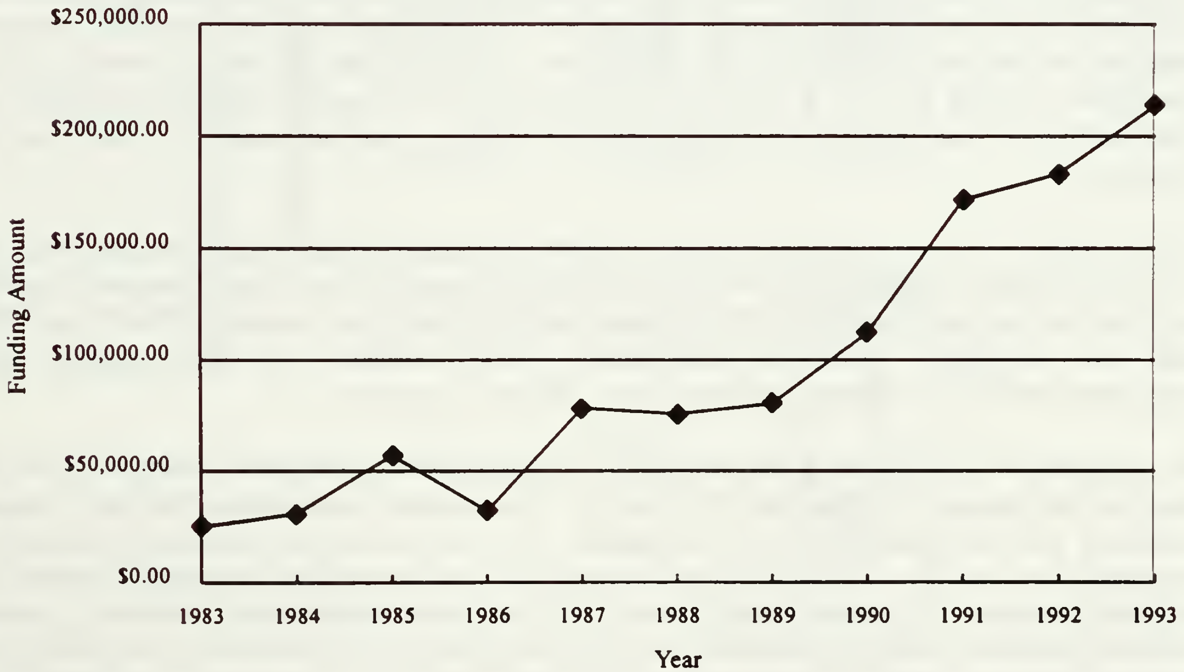


Figure 3: DRBC/NPS funding for Scenic Rivers Monitoring Program (includes field staff, contract laboratory analyses, equipment and supplies)

II.C.3 Program Operations

The Scenic Rivers Monitoring Program conducted its operations using an inter-agency integrated staff approach. The program was governed by a "planning team" which consisted of DRBC water quality professionals, National Park Service resource managers, and the DWGNRA biological technician who was historically a full-time, temporary position responsible for the laboratory and other facets of the monitoring program. DWGNRA provided a small water laboratory located in the northern part of the recreation area where it was accessible to the UDSRR staff and DRBC staff working in the region.

Overall management of the program was a responsibility of Commission staff. This staff prepared the annual quality assurance and program design plan, designed sampling protocols including special studies, provided the quality assurance officer and the program manager, and wrote and published the program's annual report. Because DRBC professional staff designed and planned the program, DRBC staff always served as the Program Manager with the Program Manager position rotating among members of the Commission's Water Quality Planning and Evaluation Section. Program management was not the Program Manager's sole duty, however, and the amount of time spent on program management each year varied depending upon factors such as the level of experience of the Assistant Manager; the level of sophistication assigned to the field staff's duties; and the Program Manager's non-program duties.

The DWGNRA technician traditionally served as the program's Assistant Program Manager, working closely with the Commission's Program Manager to insure that the sampling design was implemented and that quality assurance protocols were maintained. The Assistant Program Manager supervised DWGNRA field crews and served as the program's overall on-site coordinator. Being located in the scenic rivers region, the Assistant Manager managed the program's day-to-day activities although close coordination was maintained with the Program Manager.

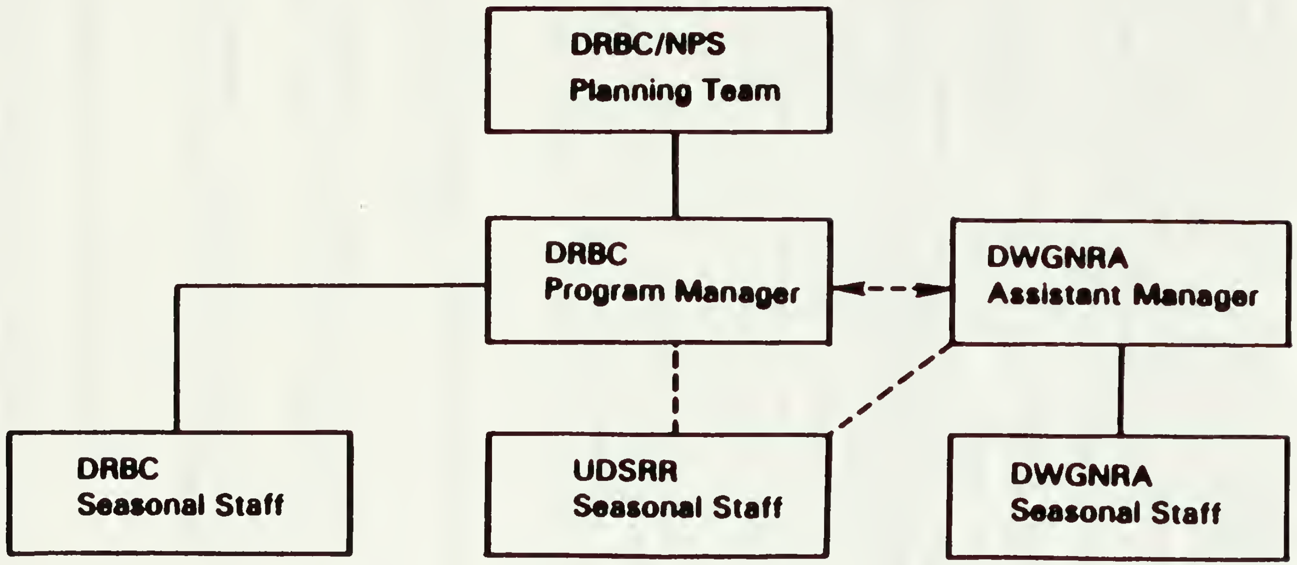
UDSRR staff were not supervised by the Assistant Manager, but received direction from the Assistant Manager. UDSRR staff participated in the early stages of each year's program planning activities and provided field crews for routine monitoring activities. Seasonal DRBC and NPS staff were historically used as field personnel. DRBC seasonal staff were generally self-supervised while NPS seasonal staff were more directly supervised.

An organization chart showing the relationship of the program participants during the first ten years of the program is presented in Figure 4. The existing organization structure worked extremely well in the early years of the program when the level of program sophistication was reasonably low and the seasonal staff very experienced. As the program expanded to include an increased number of National Park Service staff and more sophisticated sampling, various problems with the existing organization structure have arisen. As the result of these trends plus the increased responsibilities inherent in the re-designed program, a new program organizational structure is being recommended (see Section VII.B Proposed Staff Reorganization).

Figure 4:

DRBC/NPS Scenic Rivers Monitoring Program

Existing Organizational Structure



The sampling season for the first ten years of the program has been approximately from May through September with the majority of data collected between late June and the end of August. In selected years, routine monitoring or special study data have been collected in April and May and October and early November.

The program operates under a U.S. EPA-approved quality assurance plan which is prepared annually before the program is initiated. The plan outlines quality control objectives as well as internal and external quality assurance checks and audits. A second report that guides program operations is the DRBC/NPS Cooperative Water Quality Monitoring Manual. This report, updated as needed, presents the program's current analytical methods, sampling protocols, and other information. The report and the quality assurance plan are used to develop an annual field manual which is given to sampling personnel to guide their activities.

The Scenic Rivers Monitoring Program publishes an annual report where data are analyzed and discussed, and findings presented. The reports are presented as a numbered series. Data collected by the program, including biological data, are stored in the U.S. EPA STORET System and used for preparing the Commission's biennial water quality assessment report prepared under Section 305(b) of the Federal Clean Water Act.

III: DESIGN CONSIDERATIONS

III.A DESIGN BASIS

The Delaware Water Gap National Recreation Area and the Upper Delaware Scenic and Recreational River are extremely valuable national resources located in the populous Eastern United States. Their natural attributes are accessible by millions of people. These natural attributes support a variety of recreational opportunities in an environment that contrasts significantly with the urban and suburban homes of most visitors. The Upper and Middle Delaware National Scenic and Recreational Rivers are the focal point for many recreation visits to the Delaware River, one of the last major U.S. rivers without a dam on its main stem and one of the most beautiful rivers anywhere.

The fact that the DWGNRA and the UDSRR are an easy ride from most visitors' homes puts them in their visitors' "neighborhoods". Early planners of the DWGNRA recognized this unique aspect of the recreation area and often referred to it as the "Central Park of Megalopolis". They predicted that the residents of the U.S. super city "Megalopolis", running from Boston to Washington D.C., would come to use the recreation area as New Yorkers use Central Park and that eventually Megalopolis would surround the park similarly to the way New York City has grown around Central Park. In some respects, this prediction has proven to be true. In the 1990's, the DWGNRA and the UDSRR face increasing recreational use due to their natural resources and proximity to large urban areas as well as increased growth and development in the surrounding watersheds. The presence of the recreation area and the UDSRR, their natural features, and the visitors that are attracted is, in turn, a major stimulus for the development seen in adjacent areas.

The "Central Park in Megalopolis" metaphor highlights the basis of any monitoring program designed for the DWGNRA and the UDSRR:

- the need to quantify the key natural resources, particularly aquatic ecosystems, that make the river unique and attractive to visitors; and,

- the need to maintain a vigil against the anthropogenic forces located along and upstream of the Delaware River that could damage it's resources.

III.B REASONS FOR REDESIGNING THE PROGRAM

There are four main reasons for evaluating the existing Scenic Rivers Monitoring Program and designing a new program. These are discussed in the following sections.

III.B.1. Need to Bring Program in Line with Available Funding

The DRBC/NPS Scenic Rivers Monitoring Program has grown from a $30,000 per year effort

in 1984 to a program costing around $214,000 in 1993. As indicated in Figure 5, the growth in program costs reflects a near straight line growth curve since 1988. This level of growth and the current level of expenditures are not sustainable. A major reason to redesign the program at this time is so that the program maximizes the amount of <u>information</u> obtained for the available dollars.

III.B.2 Program Age

One of the dangers of operating any monitoring program is that the program will create its own inertia. Programs that run unchanged year after year with no evaluation of goals, objectives, and needs have a tendency to stagnate and to become inefficient. The Scenic Rivers Monitoring Program has, to some extent, avoided these problems by requiring that annual reports be prepared. The age of the program, however, indicates a need for a full evaluation of the program's premises, protocols, operations, and other factors.

III.B.3 Increased Responsibilities

The DRBC/NPS Scenic Rivers Monitoring Program currently has more responsibilities than it did when it was first established. The DRBC Special Protection Waters regulations, in particular, has implicit water quality monitoring and data needs. These include data needs for assessing compliance, for determining pollution control requirements, for developing watershed priorities, and others.

III.B.4 Assess the Impacts of Park Service Activities

The National Park Service, particularly the Delaware Water Gap National Recreation Area, has an operational territory immediately adjacent to waters classified as Outstanding Basin Waters. As a resource management agency directly involved with managing the Special Protection Waters, the National Park Service has a responsibility to insure that its facilities and operations do not create water quality problems and that its water pollution control activities serve as a model for the region. Water quality monitoring of various park service activities will provide the information needed by management to make operational decisions.

III.C PROGRAM GOALS

Goals for guiding future monitoring activities of the DRBC/NPS Scenic Rivers Monitoring Program are promulgated below. The goals integrate the past and future DRBC/NPS Scenic Rivers Monitoring Program with the recently adopted Special Protection Waters regulations. The manner in which the integration occurs results in a change in emphasis of current monitoring efforts from a purely water quality focus to one that is ecosystem and compliance-oriented.

PROGRAM GOAL 1: ASSESS WHETHER "EXISTING WATER QUALITY" IS "MEASURABLY CHANGING"

The overall policy of the Special Protection Waters regulations is that existing water quality in the classified Special Protection Waters will not be measurably changed as described in the

regulations. The only way managers can determine compliance with this policy is through water quality monitoring with an adequate level of statistical confidence.

PROGRAM GOAL 2: EXPAND THE SCOPE OF MONITORING TO PROVIDE AN ECOSYSTEM MONITORING STRATEGY THAT COMPLEMENTS BASELINE MONITORING

This goal integrates water quality, hydraulic, biological, and other information to develop scientific representations of the key UDSRR and DWGNRA aquatic ecosystem/habitats. The ecosystem strategy will determine over time (1) the <u>components</u> of the freshwater ecosystem contained in, and dependent upon, the Delaware River and its tributaries; (2) the interrelationships between aquatic flora and fauna, in-stream habitat conditions, biogeochemical cycles, and spatial and temporal considerations; and (3) the health and vulnerability of the various freshwater ecosystems. Derived from these assessments will ultimately be an ecosystem monitoring component that is integrated with, or supplants, the baseline monitoring component.

PROGRAM GOAL 3: PROVIDE SCIENTIFIC AND TECHNICAL INPUT TO MANAGEMENT DECISIONS

Data collected by a monitoring program is valueless unless it provides managers with information or tools for decision-making. These include water quality and problem assessments, models for assessing future scenarios, and others. Under this goal is the development of potential new (i.e., additional) criteria defining Existing Water Quality under the Commission's Special Protection Waters regulations or new definitions at Boundary Control Points.

IV: BASELINE MONITORING ELEMENT

IV.A INTRODUCTION TO BASELINE MONITORING

The following sections examine the three critical decisions inherent in the design of a baseline monitoring program: site selection; monitoring frequency; and parameters (biological parameters are covered in Section V). Merged into the decision-making process as well are concerns about staff time; available staff, staff expertise and other staff resources; other needed resources; and questions concerning the program's ability to carry out the final selected monitoring design. As a result, the implementation of the proposed baseline monitoring program carries with it risks that need to be frequently evaluated.

The philosophy used to develop the recommended baseline monitoring element was to design a program as scientifically as possible without relying on the subjective opinions derived from the participants in the past Scenic Rivers Monitoring Program. The methods used are described in the text. These included statistical evaluations of available water quality data, literature reviews, and the results of a water quality and biological workshop.

IV.B SITE SELECTION

IV.B.1 DISCUSSION

IV.B.1.a Special Protection Waters Control Points

The Special Protection Waters regulations that classify the waters within the UDSRR and the DWGNRA as Outstanding Basin Waters contain two classes of control points, defined in the regulations as follows:

> **Interstate Special Protection Waters Control Points** are general locations used to assess water quality for purposes of defining and protecting Existing Water Quality; and,
>
> **Boundary Control Points** are locations where monitoring and other activities occur to determine existing water quality, no measurable change, and related pollution control requirements as applicable. Boundary Control Points for Outstanding Basin Waters will generally correspond to federally-established boundaries for national parks, etc. A boundary control point is located everywhere a tributary or the Delaware River cross a National Park Service boundary. Precise locations of these points are available from survey maps and via Geographic Information Systems (GIS).

The Special Protection Waters regulations contains 11 and 9 Interstate Special Protection Waters Control Points and 41 and 28 Boundary Control Points for the UDSRR and DWGNRA, respectively. In addition, 4 Special Protection Waters Control Points upstream of the DWGNRA northern boundary are of major importance to the recreation area because of the urbanization in

the Port Jervis, New York metropolitan area (see Table 2 in DRBC, 1992).

The array of control points surrounding and within the UDSRR and the DWGNRA represent the first line of defense against human impacts and their potential for causing changes to existing water quality and ecological resources. Because control point monitoring is one of the goals of the monitoring program redesign, most monitoring locations have been selected for their ability to directly, or indirectly, serve as control point monitoring locations.

IV.B.1.b Redundant Monitoring Locations

In its ten year history, the Scenic Rivers Monitoring Program has collected data from 172 river and tributary locations (see Appendix A: List of SRMP Reports). At some sites extensive data has been collected over the ten year period while at other locations, sampling has occurred for short time periods, or very minimally. Data for 145 of these sites are stored in STORET.

Of the 172 total sampling sites:

- 73 are river sites;
- 99 are tributary sites;
- 68 are in, or immediately upstream, of the UDSRR corridor (including 23 river sites);
- 18 are located within the eight mile section from the downstream boundary of the UDSRR and the upstream boundary of the DWGNRA; and,
- 86 are in, or immediately upstream of, the DWGNRA (including 33 river sites).

As the list indicates, the Scenic Rivers Monitoring Program currently has an excessive number of water quality monitoring locations. A major design question is whether sites in the same vicinity, the same tributary, or the same river reach can be consolidated without losing information. The data obtained from the sites were used to answer this question.

IV.B.1.c. Monitoring Location Selection Criteria

The following site selection criteria were used:

- Locational considerations:
- Water quality;
- Drainage area size considerations;
- Monitoring sites should be consolidated wherever possible;
- Whenever possible, river sites should be selected near USGS flow gages and/or

at bridges in order to facilitate cold-weather and high flow monitoring;

- Where bridge sampling locations are not available, public access areas should be used to the extent possible;

- If any river or tributary location is statistically significantly different from other or similarly situated sites, the location should automatically be selected for future monitoring;

- When all other considerations are fulfilled, monitoring location selection should be based on which locations are most accessible and safe to monitoring personnel.

IV.B.2 ANALYSES OF POTENTIAL DELAWARE RIVER BASELINE MONITORING LOCATIONS

IV.B.2.a River Method 1: Analyses of River Locations by Water Quality

In order to determine opportunities for consolidating sampling sites, existing water quality data (dates varied by location) from various sites were statistically analyzed and compared. The analyses consisted of retrieving the data, grouping the data by site and river reach, converting the data to logarithmic values, testing for normality, and, finally, comparing the data by parameter for each site against each other site in the group. Tributary groups, presented in subsequent sections, consisted of two groups: UDSRR tributaries and DWGNRA tributaries while Delaware River groups consisted of three groups: UDSRR river sites; sites in the Port Jervis area; and DWGNRA sites. Overlapping sites were used for both upstream and downstream river groups e.g., Millrift was analyzed with both the UDSRR and Port Jervis groups.

The statistical method used to compare both river and tributary sites was the one way analysis of variance using the Duncan's Multiple Range (a parametric test) and the Student-Neuman-Keuls (a non-parametric test) Tests (SAS Institute, Inc., 1990). Both methods are multiple stage tests that, via SAS computer programs, test the homogeneity of the data means by ranking the means in ascending or descending order and determining if the differences between the observed means are statistically significant. The computer-generated output results in two lists (one for each test method) where the means are listed in ascending rank order and assigned to a group of statistically-similar means (e.g., all "A" locations were statistically identical to each other, but statistically different from all "E" locations).

The following table demonstrates type of outputs derived from the statistical analyses. Five different tributaries are statistically analyzed for a particular parameter. Based on the results, it can be stated definatively that Tributaries 1 and 2 are distinctly different from than other tributaries except Tributary 3. The same can not be stated for Tributary 3, however, because it is not statistically different than Tributaries 4 and 5.

GROUP		MEAN	TRIBUTARY
A		1.9	Trib 1
A		1.8	Trib 2
A	B	1.7	Trib 3
	B	1.2	Trib 10
	B	1.3	Trib 6

While all statistical methods have strengths and weaknesses and other methods could have been employed, the Duncan's Multiple Range and Student-Neuman-Keuls methods yielded findings that could be anticipated based on the knowledge of water quality in the scenic rivers region. Both tests were, therefore, considered reliable for screening water quality monitoring sites.

In addition to the statistical analyses, the evaluation of river sites also included an examination of the rank order of the data means from upstream to downstream. If an upstream to downstream relationship was observed (i.e., descending order of concentrations), the relationship was considered in the screening of potential monitoring sites. If, in the above table, tributaries were river sites and "Tribs 1, 2, and 3" were found to be locations arrayed in an upstream (Trib 1) to downstream (Trib 3) order, an inference can be made that the "A group" is significant because of Trib 1.

In the analyses, location was used as the variable with statistics done for seven parameters: dissolved oxygen, pH, conductivity, fecal coliform, total Kjeldahl nitrogen (TKN), nitrite+nitrate, and total phosphorus. The results of the river analyses are presented below.

Group 1, UDSRR River Locations: (East Branch, West Branch, Buckingham, Lordville, Kellams Bridge, Callicoon 1 (NY), Callicoon 2 (PA), Damascus, Milanville, Skinners, Narrowsburg, Lackawaxen 1 (Above), Lackawaxen 2 (Below), Barryville, Shohola, Pond Eddy 1, Pond Eddy 2, Millrift)

Findings:

- **Is the water quality at any UDSRR location significantly different from other UDSRR locations?** Significantly different locations were West Branch (dissolved oxygen, and nitrite+nitrate); Callicoon (dissolved oxygen, conductivity, pH (possibly), fecal coliform, total phosphorus); and Buckingham (nitrite+nitrate). Minor (or potential) significant difference was observed for Milanville (fecal coliform), but this finding is discounted due to the limited number of samples from Milanville.

- **Does monitoring at adjacent and nearby sampling locations yield any additional information?** Pairs of locations were examined for their similarity. Pairs consisted of Buckingham/Lordville, Callicoon 1 & 2, Barryville/Shohola, Lackawaxen 1 & 2, and Milanville/Skinners Falls. The only paired locations where major significant differences were observed were the two Callicoon locations which showed differences for dissolved

oxygen, conductivity, pH, and total phosphorus but not for fecal coliform, TKN, or nitrite+nitrate. A possible difference in the two Lackawaxen sites occurs for dissolved oxygen. Since these two sites are affected differently by Lake Wallenpaupack reservoir releases (one is above the Lackawaxen confluence, the other below), the possible difference probably reflects a real situation that requires further investigation.

Group 2, Port Jervis Area Locations: (Millrift, N. Port Jervis, Matamoras, Port Jervis, Route 209 Bridge, Above Neversink, Route 84 Bridge, Above Milford, Northern DWGNRA Boundary)

Findings:

- **Is the water quality at any Port Jervis Area locations significantly different from other monitoring locations in the area?** The statistical analyses indicated that no significant differences existed between any of the Port Jervis sites for all parameters. Although their geometric means were not significantly different, the relationship between rank order of concentration and upstream-downstream order exists in the reach between Neversink and Northern DWGNRA boundary for nitrate and total phosphorus, indicating a need for further investigation. Finally, the analyses suggests that the Route 209 Bridge is a particularly good reference location for this entire reach since its water quality is generally within the ranges of all the other locations.

- **Is there any significant difference between monitoring at Millrift versus monitoring at the Route 209 Bridge.** Millrift, as the southern boundary of the UDSRR, has political importance as a monitoring location while the Route 209 Bridge has practical advantages as a bridge sampling site with a continuous flow gage. Analyses were conducted to determine whether monitoring at the Route 209 bridge would be representative of water quality at Millrift. The analyses indicated that the two sites yielded essentially the same water quality information i.e., no statistical differences were noted.

Group 3, DWGNRA River Locations: (Northern DWGNRA Boundary, Milford, Dingmans, Eshback, Depew, Poxono, Bushkill, Smithfield, Worthington, Kittatinny)

Findings:

- **Is the water quality in DWGNRA locations significantly different from each other?** The statistical analyses indicated that significant differences between locations were observed for dissolved oxygen, fecal coliform, and total phosphorus. The dissolved oxygen analyses contained 4 to 5 distinct, but overlapping groups, thus yielding little in the way of specific information. Kittatinny (a location in the Delaware Water Gap) had the lowest mean and the analyses suggest it might be a distinct site from the majority (but not all) of the remaining sites.

  Fecal coliform also had overlapping groups. More importantly was the ranking of the fecal coliform means which clearly indicated a declining upstream to downstream order from the northern DWGNRA boundary to Dingmans. The pattern was repeated at Worthington and Kittatinny. This finding is suggestive of the impacts from urbanized areas i.e., the Port Jervis to Milford area in the north and the Shawnee, Brodhead, and/or

Cherry Watersheds in the south.

Although major differences between groups of locations were not indicated, an upstream to downstream pattern was also observed for nitrite+nitrate. Declining values were observed for the entire northern DWGNRA boundary to Bushkill reach. A difference was suggested by the analyses at the Poxono location for total phosphorus, but this can be accounted for by sampling frequency differences between it and other locations.

IV.B.2.b River Methods 2 and 3: Analyses of River Locations by Drainage Area

Discussion

Monitoring sites can also be selected to optimize some factor. Sharp (in Sanders et al., 1983) describes a procedure for selecting monitoring locations by sub-dividing the sampling area into hierarchical regions based on the cumulative distribution of a factor of choice such as the drainage area, number of outfalls, BOD_5 loadings, number of tributaries and so forth.

A monitoring program based <u>purely</u> on drainage area considerations assumes that water quality is relatively uniform over the watershed. This is largely the case in the scenic rivers region with the exception that the monitoring program's interest in water quality information increases as the distance to the Delaware River decreases i.e., the program is interested in water in the Delaware River and nearby tributary locations. The drainage area method uses percent of total drainage area to select and prioritize potential river monitoring locations i.e., to uniformly distribute the drainage area to allocate monitoring locations.

The first step in the process is to determine the midpoint, or first hierarchy, of the all monitoring locations. This is done by dividing the total drainage area by two to find the mid-point location that represents 50% of the total drainage area. The second hierarchy locations are determined by dividing the drainage area into quarters to find the locations corresponding to 25% and 75% of the drainage area. Third hierarchical locations are those obtained by dividing the drainage area in eighths to find the locations corresponding to 12.5%, 37.5%, 62.5%, and 87.5%. Since dividing the drainage area will never result in the selection of the most downstream location (i.e., 100% of the drainage area), it is automatically selected for monitoring.

Two alternatives of the hierarchical system were applied the scenic rivers reach of the Delaware River. Rather than find precise locations where certain percents of the drainage area exist, the monitoring site selection criteria were employed to locate potential nearby sampling sites.

Drainage Area Method: Alternative A

Alternative A considers the entire drainage area to the Delaware Water Gap as a unit without special consideration for large tributary watershed areas. This alternative is the most unbiased method.

To find the midpoint of the drainage area, the drainage area at the Delaware Water Gap (4174 square miles) was divided by two. The location closest approximating a 50 percent of the drainage area was determined to be a location above the Lackawaxen River confluence (1st

hierarchy location with 48.7%). Dividing the total drainage area into quarters determined the second hierarchial locations which included Port Jervis (2nd hierarchy location with 73.7%). Dividing again determined the third hierarchical locations which included Lordville (3rd hierarchy location with 38.2%), below confluence of the Lackawaxen (3rd hierarchy location with 63.1%), and Bushkill (3rd hierarchy with 86.8%). Delaware Water Gap would also be monitored (100%)

Because the East Branch and West Branch collectively represent almost 36% of the drainage area, one 2nd hierarchy location (i.e., 25%) and one third hierarchy location (i.e., 12.5%) are located within these two watersheds respectively. Rather than locate these locations precisely within their respective watersheds, monitoring locations for the West and East Branches would be retained at Hancock, New York since these locations also serve as Boundary Control Points.

The following summarizes the Drainage Area Method A Delaware River monitoring locations:

- UDSRR: West Branch
East Branch
Lordville
Above Lackawaxen River
Below Lackawaxen River
Port Jervis (assigned to DWGNRA for sampling)

- DWGNRA Bushkill
Delaware Water Gap at Arrow Island

Drainage Area Method: Alternative B

The scenic rivers region drains a total area of 4174 square miles as measured at the Delaware Water Gap. Of this total drainage area, the eight largest tributaries drain a collective area of 3204 square miles, or 77 percent of the total drainage area. These tributaries and their percent drainage area are the East Branch, 20.1%; the West Branch, 15.7%; Callicoon Creek, 2.7%; Lackawaxen River, 14.4%; Mongaup River, 5.0%; Neversink River, 8.4%; Bushkill Creek, 3.8%; and Brodhead Creek, 6.9%.

An alternative monitoring design is to assume that a redesigned monitoring program has already decided to establish a monitoring location on each of these tributaries. The hierarchical system is then used to allocate monitoring locations to the remaining 23% of the drainage area.

The midpoint of this drainage area is the total drainage area to the Delaware Water Gap minus the drainage area of the eight largest tributaries divided by two. The monitoring location that corresponds to this point in the drainage area is the Barryville-Shohola Bridge. This location is the first-hierarchy sampling location for Alternative B.

Dividing the drainage area into quarters to find the locations representing 25% and 75% of the drainage area. These locations are the second-hierarchy sampling locations: the Cochecton-Damascus Bridge (24%) and Milford Beach (75.2%).

Dividing by 2 again determines the third-hierarchy sampling locations (corresponding to 12.5%,

37.5%, 62.6% and 87.5%). Locations corresponding to these locations are (a) a location between the Kellams (8%) and Callicoon (22.6%) bridges that can be determined if needed; (b) Tenmile River Access (38.8%); (c) Pond Eddy bridge (64.3%); and (d) Eshback or Bushkill Access Areas (89.2%).

The following summarizes the Drainage Area Method B Delaware River monitoring locations:

- UDSRR: Between Kellams & Callicoon
  Cochecton
  Tenmile River Access
  Barryville
  Pond Eddy

- DWGNRA: Milford Beach
  Eshback or Bushkill
  Delaware Water Gap at Arrow Island

IV.B.2.c River Method 4: Analyses of River Locations by Uniform Distance

Another method of selecting potential river monitoring locations is to select sites on the basis of some uniform distance between each site i.e., every 10 miles, 15 miles etc. In a river like the Delaware River, an arbitrary (or even scientifically-justifiable) method will yield many potential sites that are inaccessible except possibly by boat. Inaccessibility violates several of the monitoring location site selection criteria presented in Section IV.B.1.c.

Human use of the Delaware River, however, leads to one possible method of allocating sampling sites. The need for river crossings and boat access areas have led to past decisions based somewhat on uniform distance. Bridge crossings, for example, are spread along the Delaware in such a manner that a person does not usually have to drive an inordinate distance to find a bridge. Similarly, boat access areas are generally established to fill a local need. Most boat access areas are not near a second access area (Narrowsburg being one of the few exceptions).

The question, therefore, is whether or not bridge and boat access areas are uniformly spaced along the Delaware River. In order to assess this, tables of bridges and access areas and their river mile locations were developed and the river mile distances between bridges and access areas examined.

With bridges being preferred over access areas, analyses were conducted to determine if a set of monitoring locations could be developed based on equidistance between monitoring locations. Three sets of alternatives were examined: 9 miles between locations, and two alternatives involving 18 miles between sites.

The best equidistance alternative in terms of the highest number of bridge sites and uniform distance between sites had an average distance between locations of 18.7 miles and a range of 18 to 20. These results are satisfactory since both the range and average are influenced by rounding the mileage to the nearest whole mile. Seven potential monitoring locations were derived from the analyses:

- UDSRR: Lordville Bridge
  Callicoon Bridge
  Tenmile River Access
  Pond Eddy Bridge

- DWGNRA: Milford Bridge or Access Area
  Bushkill Access Area
  downstream end of the DWGNRA

The Narrowsburg Bridge could be substituted for the Tenmile River Access Area when river conditions warranted (e.g., high flows).

IV.B.3 ANALYSES OF POTENTIAL TRIBUTARY BASELINE MONITORING LOCATIONS

VI.B.3.a Tributary Method 1: Comparisons by Water Quality Concentrations

Water quality similarities between tributaries were examined in the same fashion as Delaware River locations as described in Section IV.B.2.a (Analyses of River Locations by Water Quality). The statistical methods used, Duncan's Multiple Range and Student-Neuman-Keuls tests, were used for examining similarities on both a concentration and load bases.

Group 4, UDSRR tributaries (32 tributaries)

Findings:

- **Is the water quality in UDSRR tributaries significantly different from each other?** Most UDSRR tributaries did not have significantly different water quality. The lone exception was Callicoon Creek which was either significantly different (conductivity, nitrite+nitrate, possibly pH) or had the highest mean of all sampled tributaries (fecal coliform). Although not substantiated statistically, Calkins Creek and the Lackawaxen River showed some uniqueness for dissolved oxygen when compared with other locations. A similar observation was noted at the Delaware River downstream from the Lackawaxen confluence monitoring location (see previous discussion in Section IV.B.2.a.)

Group 5, DWGNRA tributaries (32 tributary locations including Cummins Creek and the Neversink River and dual locations on some individual DWGNRA tributaries)

Findings:

- **Is the water quality in DWGNRA tributaries significantly different from each other?** As a whole, statistically-significant differences were observed for each parameter with some parameters having many overlapping groups. In order to interpret the information, the tributaries were ranked according to how many times their means appeared in either the highest or lowest group, whichever reflected worse water quality. Ten tributaries received 2 or more "hits" in this ranking system. These tributaries and the number of "hits" were: Cherry (6); Shawnee (5); Little Flatbrook (4); Shimers and Neversink (3);

and Vandermark, Brodhead, Little Bushkill, Flatbrook, and Marshalls (2). These findings are not unexpected since each reflects known urban or agricultural inputs.

- **Is there any significant difference between monitoring at the DWGNRA boundaries or sites near their confluence with the Delaware River?** Parallel data for Adams, Dingmans, Toms, Bushkill, Flatbrook, Shawnee, Brodhead, and Cherry Creeks indicated only one tributary where there was a significant difference between sampling sites on the same tributary. The exception was Cherry Creek. Its two monitoring sites were significantly different in terms of fecal coliform i.e., the sites were not measuring essentially the same water quality. Based on the sources of fecal coliform affecting water quality in Cherry Creek, this observation could have been predicted.

VI.B.3.b Tributary Method 2: Comparisons by Load (concentration-flow relationships)

Watersheds in the upper Delaware River Basin vary greatly in size with larger watersheds delivering more water than smaller watersheds. The differences in the flow regimes can mask water quality differences by diluting concentrations of pollutants.

In order to assess whether or not significant water quality information is being hidden by flow, analyses were done (where adequate flow data were available) to determine load-flow relationships. The first step in the process was to pair water quality data with the flow data collected at the time of sampling. Data for Cherry, Shawnee, Van Campens, Shimers, Dingmans, Sawkill, Vandermark, Beaverdam, Little Bushkill, and Shohola were used for the small tributaries analyses and Lackawaxen, Neversink, Bushkill, Flatbrook, and Brodhead were used for the large tributaries analyses. All tributaries were not subject to these analyses because of the lack of flow data. Small tributary analyses used flow data collected by the Scenic Rivers Monitoring Program while the large tributary analyses used daily flow data from U.S. Geological Survey gages.

Mean loadings for each parameter: BOD_5, fecal coliform, ammonia+ammonium, total Kjeldahl nitrogen (TKN), nitrite+nitrate, total phosphorus, total suspended solids and total dissolved solids were calculated and used to develop flow-weighted loads. These loads were compared statistically to determine significant differences.

The following locations differed significantly when compared to other locations (Note: Shohola is biased by limited data):

Findings for Small Tributaries:

- BOD_5: Cherry and Shohola
- Fecal coliform: None
- Ammonia+ammonium: Cherry
- TKN: Cherry and possibly Shohola and Little Bushkill
- Nitrite+nitrate: Cherry

- Total phosphorus: Cherry
- Total suspended solids: Cherry
- Total dissolved solids: Shohola and Cherry

Findings for Large Tributaries:

- BOD_5: Neversink and Lackawaxen
- Fecal coliform: Neversink
- Ammonia+ammonium: Neversink
- TKN: Neversink
- Nitrite+nitrate: Neversink
- Total phosphorus: Neversink
- Total suspended solids: None
- Total dissolved solids: Neversink

The second part of the analyses was to explore the relationship of watershed size to the flow-weighted load. To do this, the flow-weighted loading for each parameter was divided by the drainage area of the specific watershed to obtain a mean pound per day per square mile value. This method differs from the previously described methods since it factors out watershed size and flow as a variable. These resulting area-unit loads as pounds per square mile were then ranked from highest to lowest. Tributaries with higher mean loading rates than other watersheds warrant consideration in the monitoring program design. Only the top-ranked tributaries and their values are presented below. Possible cutoff points are suggested by the rankings.

Findings for Small Tributaries:

- BOD_5: Cherry (19.3); Vandermark (4.0); remaining locations from 0.05 to 2.5
- Fecal coliform: Cherry (4940); Shawnee (1375); Vandermark (1007); remaining locations from 2 to 438
- Ammonia+ammonium: Cherry (1.21); Vandermark (0.21), remaining locations from 0.05 to 0.12
- TKN: Cherry (6.65); Van Campens (2.93); Vandermark (2.76); Little Bushkill (2.28); remaining from 1.02 to 1.45
- Nitrite+nitrate: Vandermark (6.78); Cherry (5.34); Sawkill (1.26); remaining less

than 1.0

- Total phosphorus: Cherry (0.80); Vandermark (0.23); remaining less than 0.12

- Total suspended solids: Cherry (238); Shimers (37); Vandermark (21); remaining are 13 or less

- Total dissolved solids: Cherry (1706); Shohola (1100); Shimers (760); Vandermark (712); remaining from 176 to 584

Findings for Large Tributaries:

- BOD_5: Flatbrook (2.45); Neversink (2.26); Lackawaxen (1.04); remaining less than 1.0

- Fecal coliform: Neversink (577); Bushkill (418); Brodhead (390); Flatbrook (356); Lackawaxen (21)

- Ammonia+ammonium: Neversink (0.27); Flatbrook (0.12); remainder below 0.10

- TKN: Flatbrook (1.55); Neversink (1.32); Lackawaxen (0.80); remainder below 0.6

- Nitrite+nitrate: Neversink (2.16); Flatbrook (0.57); remainder below 0.5

- Total phosphorus: Neversink (0.35); Bushkill (0.14); Brodhead (0.10); remainder less than 0.10

- Total suspended solids: Neversink (19.7); Flatbrook (12.6); Lackawaxen (8.6); remaining below 7.0

- Total dissolved solids: Flatbrook (676); Neversink (338); Bushkill (129); remainder below 100

IV.B.3.c Tributary Method 3: Comparison by Drainage Area Size

The approximately 70 watersheds that drain the scenic rivers region vary in size from about 1 square mile to over 800 square miles. Since the Scenic Rivers Monitoring Program's interest in each tributary is a location near its confluence with the Delaware River, drainage area size is an important factor for selecting potential sampling sites. Selecting the largest tributaries for priority sampling is logical for two reasons: (1) the costs for monitoring a large watershed yields the most bang-for-the-buck because each sample represents a larger area; and (2) larger watersheds will, in general, have a more significant impact on Delaware River water quality than a smaller one.

Table 1 presents the 20 largest watersheds by rank order. Converting each watershed's drainage area to percent of total drainage area allows an analysis of the cumulative percentage of drainage

area. As indicated, the 3 largest watersheds account for 50 percent of the drainage area with the 7 largest watersheds accounting for 75 percent of the total scenic rivers drainage area. The 20 largest watersheds account for 89 percent of the drainage area with the remaining 50 watersheds (plus direct drainage) only draining 11 percent collectively.

IV.B.4 SELECTION OF BASELINE WATER QUALITY MONITORING LOCATIONS

IV.B.4.a Delaware River Locations

In Section IV.B.2 (Analysis of Potential Delaware River Baseline Monitoring Locations), four methods were used to derive potential river sampling locations; water quality, drainage area (Methods A and B), and equidistance. Any one of these four methods is valid for selecting monitoring locations.

Review of the results of the four methods indicates that, with minor adjustment, the four methods can be combined to yield a recommended sampling strategy, an ideal situation that negates the need for selecting one method over the others. The minor adjustment involves several instances where sites are substituted: Lordville for Buckingham (water quality method); Lordville and Callicoon Bridge for "Between Kellams and Callicoon (drainage area 2); Tenmile River Access Area for Above Lackawaxen River (drainage area 1); and Barryville for Below Lackawaxen River. Analyses previously indicated that most locations were not significantly different in terms of water quality, thus allowing these minor adjustments.

Two additional Delaware River locations within the DWGNRA were selected in order to more comprehensively evaluate "Existing Water Quality" under the Special Protection Waters regulations. <u>It is important to note that each method used to generate a set of monitoring locations is also a method for analyzing the results of monitoring.</u> Data from individual sites, therefore, will be evaluated as part of subsets of locations (corresponding to water quality, drainage area 1 etc.) as well as collectively.

The final list of Delaware River baseline monitoring locations contains 14 monitoring locations (see Table 2); 8 locations for the UDSRR (including Port Jervis, to be sampled by the DWGNRA) and 7 for the DWGNRA including Port Jervis. These sites represent the baseline monitoring sites for at least the next three years. After sufficient data are collected, site selection should be reevaluated.

Where a state or local water quality monitoring program is deemed to be adequately monitoring one or more of these locations, the Scenic Rivers Monitoring Program will rely on the other agency's data and not monitor the site.

Table 1: Twenty Largest Tributary Watersheds by Size

Rank	Tributary	Drainage Area Size (mi^2)	% of Total (rounded)	Cumulative %
1	East Branch of Delaware River	840	20	20
7	West Branch of Delaware River	666	16	36
3	Lackawaxen River	597	16	50
7	Neversink River	350	8	59
5	Brodhead Creek	294	7	66
6	Mongaup River	294	8	71
7	Bushkill Creek	157	7	85
7	Callicoon Creek	111	3	77
9	Shohola Creek	28	2	79
10	Flatbrook	65	2	71
11	Equinunk Creek	58	1	82
12	Tenmile River	49	1	83
13	Calkins Creek	44	1	87
14	Raymondskill Creek	35	1	85
16	Masthope Creek	32	1	86
16	Halfway Brook	28	1	87
17	Shinglekill	28	1	87
18	Little Equinunk Creek	25	1	85
19	Sawkill Creek	25	1	85
20	Beaver Brook	23	1	85
All other tributaries and direct drainage		458	11	100

IV.B.4.b Tributaries Selected for Monitoring

Tributary locations were selected based on drainage size (the 20 largest watersheds were selected), water quality considerations, and Special Protection Waters Boundary Control Point needs. The 27 tributary watersheds selected for monitoring are presented in Table 2. Fourteen of the twenty largest tributaries are within the UDSRR and 6 are in the DWGNRA, but seven additional DWGNRA tributaries require monitoring and special studies due to either the findings of the water quality analyses or the need to monitor a major tributary branch (i.e., Little Bushkill and Little Flatbrook). These represent the baseline monitoring sites for at least the next three years. After sufficient data are collected, the program should evaluate and determine if changes to the initial tributary list are warranted.

Where a state or local water quality monitoring program is deemed to be adequately monitoring one or more of these locations, the Scenic Rivers Monitoring Program will rely on the other agency's data rather than conducting redundant monitoring.

Tributary watersheds not selected for monitoring are possible candidates for monitoring by the several citizen monitoring programs operating in the scenic rivers region. Commission and National Park Service staff will work with these groups to determine if these other programs can cover locations that were not selected. Flexibility should be provided in the Scenic Rivers Monitoring Program to allow unselected watersheds to be monitored as the need arises.

IV.C SELECTION OF MONITORING FREQUENCY

IV.C.1 Biweekly Versus Monthly

A major goal for redesigning the Scenic Rivers Monitoring Program is to develop a cost-effective program that obtains information within the program's budget. Cost-effectiveness implies that the desired level of water quality information is acquired at the lowest possible cost.

Since its inception, the Scenic Rivers Monitoring Program has generally used a biweekly sampling routine to collect its baseline data. A question that needs to be answered is whether or not this sampling frequency is cost-effective. Reducing sampling frequencies has some implications concerning statistical analyses as discussed later in Section VII.G.2 (Program Statistics).

In order to evaluate whether or not the program can reduce its sampling in half (i.e., monthly) existing water quality data for selected locations were evaluated. The evaluation consisted of a comparison of a whole data set to one where every other site visit was removed from the data set. The statistical method used to compare the whole versus the half data sets was the one way analysis of variance using the Duncan's Multiple Range and the Student-Neuman-Keuls Tests as used above. Parameters examined were: dissolved oxygen, pH, conductivity, fecal coliform, total Kjeldahl nitrogen, nitrite+nitrate, and total phosphorus. The locations evaluated were four river sites (Buckingham, Barryville, Milford, and Delaware Water Gap) and four tributaries (Callicoon Creek, Shohola Creek, Bushkill Creek, and Brodhead Creek).

Table 2: Selected Monitoring Locations

Selected Monitoring Location	Method of Selection
UPPER DELAWARE SCENIC AND RECREATIONAL RIVER	
DR @ Lordville Bridge	water quality; drainage area 1 and 2; equidistance
DR @ Callicoon Bridge	drainage area 1 and 2; equidistance
DR @ Callicoon Access Area	water quality
DR @ Cochecton Bridge	drainage area 2
DR @ Tenmile River Access Area	drainage area 1 and 2; equidistance
DR @ Barryville Bridge	drainage area 2
DR @ Pond Eddy Bridge	drainage area 2; equidistance
DR @ Port Jervis (RT 209 Bridge)[2]	water quality; drainage area 1
DELAWARE WATER GAP NATIONAL RECREATION AREA	
DR @ Port Jervis (RT 209 Bridge)[2]	water quality; drainage area 1
DR @ Northern DWGNRA boundary	water quality
DR @ Milford Access	drainage area 2; equidistance
DR @ Dingmans Access	Special Protection Waters
DR @ Bushkill Access	drainage area 1 and 2; equidistance
DR @ Smithfield Access	Special Protection Waters
DR @ Delaware Water Gap at Arrow Island	drainage area 1 and 2; equidistance
UPPER DELAWARE SCENIC AND RECREATIONAL RIVER WATERSHEDS	
East Branch of Delaware River	drainage area 2; drainage area size
West Branch of Delaware River	drainage area 2; water quality; drainage area size
Equinunk Creek	drainage area size
Little Equinunk Creek	drainage area size
Calkins Creek	drainage area size
Callicoon Creek	drainage area 2; water quality (concentration); drainage area size
Tenmile River	drainage area size
Masthope Creek	drainage area size
Beaver Brook	drainage area size
Lackawaxen River	drainage area 2; water quality (load and flow-weighted load); drainage area size
Halfway Brook	drainage area size
Shohola Creek	water quality (load and flow-weighted load); drainage area size
Mongaup River	drainage area 2; drainage area size
Shinglekill	drainage area size

[2] Sampled by DWGNRA.

Selected Monitoring Location	Method of Selection
DELAWARE WATER GAP NATIONAL RECREATION AREA WATERSHEDS	
Neversink River	drainage area 2; water quality (concentration, load, and flow-weighted load); drainage area size
Vandermark Creek	water quality (concentration and flow-weighted load)
Shimers Brook	water quality (concentration and flow-weighted load)
Sawkill Creek	water quality (flow-weighted load); drainage area size
Raymondskill Creek	drainage area size
Bushkill Creek	drainage area 2; water quality (flow-weighted load); drainage area size
Little Bushkill Creek	water quality (concentration, load, and flow-weighted load)
Flatbrook	water quality (concentration and flow-weighted load); drainage area size
Little Flatbrook	water quality (concentration)
Van Campens Brook	water quality (flow-weighted load, TKN only)
Shawnee Creek	water quality (concentration and flow-weighted load)
Brodhead Creek	drainage area 2; water quality (concentration and flow-weighted load); drainage area size
Cherry Creek	water quality (concentration, load, and flow-weighted load)

Findings:

The analyses indicated that no information would be lost if sampling frequency was reduced from biweekly to monthly. At every location and for every parameter, the information (i.e., the log means) were statistically similar as well as numerically similar. Based on previous analyses, it is assumed that this relationship is true for all other monitoring locations as well. A baseline monitoring program based on monthly sampling is, therefore, recommended. The selection of a monthly sampling schedule, however, does not preclude the need for weekly sampling of fecal bacteria at bathing beaches.

IV.D SELECTION OF PARAMETERS AND METHODS

IV.D.1 BACTERIAL

Fecal coliform have been measured by the DRBC/NPS program from its inception and has proven to be a sensitive indicator of water pollution problems, particularly during dry weather. Fecal streptococcus have also been measured. E. coli was measured during 1992, and was found to correlate well with fecal coliform (Huff, 1993). The DRBC/NPS will continue to test Fecal coliform using the membrane filtration method. A test procedure currently employed by DRBC in the Delaware Estuary, which obtains values for both Fecal coliform and E. coli, will be phased in over time.

IV.D.2 CHEMICAL/PHYSICAL

IV.D.2.a. Flow and Gage Height Measurements

There are five USGS continuous recording gaging stations located on the Delaware River and eight on tributaries in the scenic rivers region. Data from these gage stations have been, and will continue to be, obtained from the USGS. The Scenic Rivers Monitoring Program has set up gaging stations to obtain discharge data for the streams that do not have USGS gaging stations. Gage height, the elevation of the water surface at a specified location as measured from a reference point, has been, and will continue to be measured every time the stream is sampled.

Table 3 presents a summary of flow measurement locations for the selected Scenic Rivers Monitoring Program sites. Flow measurement capabilities are being established for three of these watersheds in 1994. In addition, instantaneous flow measuring capabilities have been established on Cummins Creek, Dingmans Creek, Hornbecks Creek, Saw Creek, Toms Creek, Marshalls Creek, and Slateford Creek. Rating curves for all streams gaged by the DRBC/NPS program as of May 1994 are contained in Report No. 16 of the DRBC/NPS Cooperative Monitoring Program.

IV.D.2.b Water Chemistry

The redesign of the Scenic Rivers Monitoring Program assumes that special funding is not available for private laboratory analyses of nutrients and other parameters and that the present DWGNRA water laboratory is not to be significantly expanded (see discussion in Section VII.C Sample Analyses). To replace the use of a private laboratory, a search of available equipment

Table 3: Summary of Flow Monitoring Capabilities

Location	**Agency**[3]	**Type**
DELAWARE RIVER		
DR @ Callicoon Access Area	USGS	Continuous
DR @ Just Upstream of Lackawaxen River	USGS	Continuous
DR @ Port Jervis	USGS	Continuous
DR @ Milford	USGS	Continuous
DR near Tocks Island	USGS	Continuous
UDSRR TRIBUTARIES		
East Branch of Delaware River	USGS	Continuous
West Branch of Delaware River	USGS	Continuous
Equinunk Creek	DRBC/NPS	Instantaneous
Little Equinunk Creek	DRBC/NPS	Instantaneous
Calkins Creek	DRBC/NPS	Instantaneous
Callicoon Creek	DRBC/NPS	Instantaneous
Tenmile River	DRBC/NPS	Instantaneous
Masthope Creek	DRBC/NPS	Instantaneous
Beaver Brook	DRBC/NPS	Instantaneous
Lackawaxen River	USGS	Continuous
Halfway Brook	DRBC/NPS	Instantaneous
Shohola Creek	DRBC/NPS	Instantaneous
Mongaup River	USGS	Continuous
Shinglekill	DRBC/NPS	Instantaneous
DWGNRA TRIBUTARIES		
Neversink River	USGS	Continuous
Vandermark Creek	DRBC/NPS	Instantaneous
Shimers Brook	DRBC/NPS	Instantaneous
Sawkill Creek	DRBC/NPS	Instantaneous
Raymondskill Creek	DRBC/NPS	Instantaneous
Bushkill Creek	USGS	Continuous
Little Bushkill Creek	DRBC/NPS	Instantaneous
Flatbrook	USGS	Continuous
Little Flatbrook	DRBC/NPS	Instantaneous
Van Campens Brook	DRBC/NPS	Instantaneous
Shawnee Creek	DRBC/NPS	Instantaneous
Brodhead Creek	USGS	Continuous
Cherry Creek	DRBC/NPS	Instantaneous

[3] USGS gages are funded by the States of New Jersey, New York, and Pennsylvania.

indicated that the use of portable colorimeter methods would be satisfactory and cost-effective. Tests for nitrite+nitrate, and ortho-phosphate can be done in the field or laboratory using prepared reagent kits. If needed, additional parameters can be analyzed at relatively low cost including ammonia, aluminum, bromine, chlorine, chlorine dioxide, chromium, COD, copper, cyanide, cyanuric acid, fluoride, hydrazine, hydrogen peroxide, iodine, iron, manganese, molybdenum, nickel, ozone, phenols, potassium, silica, sulfate, sulfide, tannin, total phosphorus, and zinc.

In 1993, DWGNRA purchased three continuous automated electronic water quality monitoring units. DRBC used these monitors to conduct an evaluation of electronic monitoring for the program. Based on the evaluation, these units will be used only for intensive, site-specific special studies. They are capable of measuring water and air temperature, dissolved oxygen, conductivity, turbidity and pH at a given time interval, and storing this information. Ion selective electrodes (ammonium, nitrate etc.), which are also available, were not found to be reliable or useful in a field setting.

The redesigned baseline monitoring program is based on a continuation of parameters and methods used successfully by the DRBC/NPS program in the past, plus the addition of several colorimetric tests as noted. The following additional baseline parameters could be implemented as funding permits (analytical equipment costs shown); total phosphorus ($0-4,000), ammonia+ammonium (approx. $800-1,000), total Kjeldahl nitrogen (approx. $5,000 to 10000), total dissolved solids and total suspended solids (approx. $3,000-5,000 for furnace and balance), chlorophyll a (equipment available), biomass (equipment same as solids), and E. coli (minor cost increases for supplies). These estimates do not include costs for staff time or routine chemicals and supplies for performing these analyses. Figures may need to be doubled if the same capabilities will be needed at both UPSRR and DWGNRA laboratories.

Table 4 presents a summary of the selected Scenic Rivers Monitoring Program water quality parameters.

Table 4: Selected Baseline Water Quality Parameters[3]

Parameter	Method	Equipment	Min - Max	Accuracy
BASELINE				
air temperature	thermometric	thermometer	-10-110 °C	± 1 °C
water temperature	thermometric	thermometer	-10-110 °C	± 1 °C
		DO meter temp. probe	-5-45 °C	± 0.7 °C
		conductivity meter temperature probe	-2-50 °C	± 0.6 °C
dissolved oxygen	azide modification of Winkler titration method	kit	0-20 mg/l	± 1 % of scale[4]
	polarigraphic membrane electrode	meter		
specific conductance	platinum electrode conductivity cell	meter	0-19,999 µmhos/cm	± 4.5 %[5]
pH	electrometric	meter	0-14 standard units	± 0.1 standard units
nitrite+nitrate	cadmium reduction	colorimeter	0.02-3.00 mg/l	± 0.15 mg/l
ortho-phosphate	ascorbic acid reduction	colorimeter	0.01-3.00 mg/l	± 0.15 mg/l
turbidity	absorbimetric	colorimeter	5-400 FTU	± 20 FTU
fecal coliform	m-FC media	membrane filtration	≥ 0 colonies/ 100 ml	NA
PARAMETERS AVAILABLE USING AUTOMATED ELECTRONIC EQUIPMENT				
water temperature	thermometric	thermistor probe	-70.0-200.0 °C	± 0.1 °C
dissolved oxygen	galvanic and polarographic membrane electrode	meter	0-20 mg/l	± 0.2 mg/l
specific conductance	carbon electrode conductivity cell	meter	0-60,000 µmhos/cm	± 0.5 %
pH	electrometric	meter	0-14.00 units	± 0.02 units
turbidity	nephelometric	meter	0-2000 NTU	± 2 %
POTENTIAL FUTURE BASELINE PARAMETERS				
total phosphorus	ascorbic acid digestion preceded by persulfate digestion		depends on equipment purchased	
ammonia+ammonium	nesslerization (colorimetric) or ion selective electrode			
total Kjeldahl nitrogen	macro Kjeldahl or Hach Digestahl			
total suspended solids	TSS dried at 103-105 °C	glass fiber filtration, oven, analytical balance		
total dissolved solids	TDS dried at 180 °C			
E. coli	m-TEC	membrane filtration	≥ 0 colonies/ 100 ml	NA
miscellaneous available	varies	colorimeter	varies	varies
miscellaneous available	ion selective electrodes	automated equipment	varies	varies

[3] For flow, see Table 2.

[4] When air temperature falls below -5 °C, meter loses accuracy, and should not be used.

V: ECOSYSTEM MONITORING ELEMENT

V.A INTRODUCTION TO ECOSYSTEM MONITORING

The baseline monitoring program focuses on the status of water quality and its relationship to the Special Protection Water's definition of existing water quality. A second element to be monitored by the redesigned Scenic Rivers Monitoring Program are aquatic ecosystems. An ecosystem is a biological community and its environment. Within a specific ecosystem, biological organisms maintain complex interrelationships between each other and the environment within which the ecosystem functions. The study of these interrelationships is the science of ecology.

Important as it is, water quality is only one of many factors that describe the environment of an ecosystem. High water quality is useless if other environmental stresses prevent aquatic ecosystems from functioning properly. These stresses could include:

- drought flows (i.e., low flows),
- flood flows (i.e., high flows),
- reservoir releases (e.g., effects of scouring, dissolved oxygen effects etc.) ,
- small and large spills of toxic materials,
- impacts from power boats and other recreational activity,
- storm water runoff,
- global climate changes,
- pressures from the introduction of exotic plants and animals, and
- a wide variety of other natural and anthropogenic stresses.

Ecosystem Monitoring involves determining:

- the chemical, biological, and physical characteristics of the ecosystem;
- the habitats within the ecosystem;
- the natural variability of the biological components of each habitat;
- the sensitivity of each biological component to natural and anthropogenic impacts;

- the interrelationship and natural variability of chemical, physical, and biological components;

- measures of the ecosystem's overall integrity and health; and,

- changes over time.

The redesign of the Scenic Rivers Monitoring Program provides an opportunity for introducing ecosystem-based monitoring to the program. Ecosystem monitoring represents a higher order of monitoring activity than one that only monitors water quality. As with water quality monitoring, the purpose of ecosystem monitoring is to obtain information needed for making sound management decisions.

The UDSRR and DWGNRA contain four broad categories of aquatic ecosystems; each with several subcategories. The following are the major categories and sub-categories of the aquatic ecosystems of interest:

- Riverine: pools, riffles and rapids, runs

- Tributary: pools, runs, riffles, intermittent streams, perennial streams

- Wetlands: riverine, lacustrine, palustrine

- Lakes and Ponds: man-made, natural, modified natural, seasonal

Within these macro-ecosystems are a variety of micro-ecosystems which, in most cases, are analogous to habitats. The inside and outside of bends, the upstream or downstream ends of islands, the upstream or downstream ends of rocks, areas with shade cover from overhanging vegetation or aquatic plant beds, gravel versus silty stream beds, and many other characteristics can be used to define the habitat structures within an ecosystem.

V.B SELECTION OF ECOSYSTEMS AND STUDY LOCATIONS

V.B.1 SELECTION OF ECOSYSTEMS

The following ecosystems were selected for emphasis: (1) tributary runs and riffles near or at NPS boundaries, and (2) Delaware River reaches with typical pool/run/riffle combinations.

V.B.2 TRIBUTARY ECOSYSTEMS

The analyses contained in IV.B indicates that most tributaries to the UDSRR and DWGNRA have similar water quality. This can be expected since most tributaries are similar in terms of gradients, underlying geology, vegetative cover, and other factors. Tributary differences are mainly due to the degree of urbanization or other human activities, local geological conditions (e.g., a limestone deposit), and whether or not they have flow during extreme low flow periods.

Essentially the same habitats can be studied in all but the largest tributaries draining to the UDSRR and DWGNRA. Each tributary is typically a cold-water stream with significant stream velocity over a rocky, gravelly stream bed with some pool areas. In these streams, ecosystem monitoring can be limited to macroinvertebrate sampling accompanied by habitat assessments. Tributary ecosystem study locations will be those selected for baseline monitoring, but will not necessarily include all the sites.

V.B.3 DELAWARE RIVER ECOSYSTEMS

The Delaware River from Hancock, New York to the Delaware Water Gap is a free-flowing, braided river with numerous islands, rapids and riffles, runs, and pools. As indicated above, the river ecosystem monitoring program will focus on pool/run/riffle combinations. These macro-habitats of the Delaware River can generally be defined as follows:

> **Pools**: Deeper areas of the river characterized by low velocities (less than 1 ft. per sec.), usually wider than average river widths, and areas of depositional material;
>
> **Runs**: A relatively uniform reach of river characterized by a smooth, unbroken surface, channel depths of 1 to 4 feet under typical low-flow conditions, a moderate flow velocity, and a general lack of depositional material; and,
>
> **Riffles and Rapids**: A relatively shallow area with fast current, disturbed water surface, and steeper gradient during typical low flow conditions.

Based on information from the DRBC's Delaware River Recreation Maps (1991), the Middle Delaware contains over 40 riffles and rapids (mainly riffles), 20 sections that can be characterized as runs, and 14 sections that can be characterized as pools while the UDSRR consists (roughly) of 109 riffles and 23 rapids. UDSRR pools and runs are generally shorter in length and less distinguishable than those in the DWGNRA. The UDSRR, however, contains notably deep pools at Narrowsburg (110 feet) and Pond Eddy (46 feet). Sharp distinctions can not be made between all pools and runs, however, without additional physical and biological data since pools are often joined to runs and vice versa. Studies, however, have shown that pools and runs can be characterized by aquatic macrophyte diversity and physical characteristics, particularly depositional material, depth, width, velocity, and other characteristics.

In August and September, 1994, a reconnaissance survey was conducted of possible study areas for the Delaware River ecosystem monitoring element. Four study areas were selected and subsequently surveyed using Global Positioning System (GPS) equipment. The data obtained from the survey is being used to develop base maps of each study area.

The selected study areas are described below.

- Vicinity of Buckingham Access Area (Stockport Creek confluence to immediately below Buckingham Access Area). This reach was selected to monitor potential inputs to the UDSRR. The area is located downstream from the junction of the East and West Branches, Delaware River and, in conjunction with information acquired from the baseline monitoring program, will provide information on the

impacts from these two large tributaries and their large watersheds.

- Vicinity of Matamoras Access Area (the downstream portion of Jerry's Eddy to Matamoras Access Area). This reach was selected to monitor the downstream end of the UDSRR and to provide background information for assessing the impacts of the Port Jervis/Matamoras/Milford urban area, located immediately downstream.

- Northern Milford Area (Orchard Eddy from the Class I rapid at the head of the eddy downstream to the mouth of Vandermark Creek). This reach was selected to assess the impacts of the Port Jervis & Matamoras area including the influence of the Neversink River. The study area represents the uppermost section of the DWGNRA and, in conjunction with information acquired from the baseline monitoring program, will provide information on the impacts from these potential sources of pollution and other environmental stressors.

- Vicinity of Bushkill Access Area (pool upstream of Bushkill Access Area downstream to riffle at the confluence of Denmark Creek). This study area represents an area with the best water quality in the DWGNRA and the study area possibly the least influenced by human impact. The expansion of National Park Service facilities at the access area may allow the assessment of potential impacts from NPS operations while potential development in the townships adjacent to the recreation area suggests the need to monitor for possible change.

V.C. SELECTION OF STUDY PROTOCOLS AND PARAMETERS

V.C.1 TRIBUTARY ECOSYSTEMS

Tributaries will initially be subjected to ecosystem analyses consisting of macroinvertebrate sampling and detailed habitat assessments. Other biological organisms may be collected at a later date depending upon observations at each site. These could include periphyton, rooted aquatic plants, and fish.

The first several years of the macroinvertebrate biomonitoring and habitat assessment activities will be conducted in accordance with a cooperative agreement with the Academy of Natural Sciences in Philadelphia. This agreement with DWGNRA (and in 1995 with UDSRR) calls for the collection of samples by DRBC and NPS biomonitoring/habitat assessment teams with analyses of the samples by the Academy. The purpose of the study will be to obtain data on biological communities in the selected tributaries while attempting to define the natural variability inherent in the communities. A major product of the study will be to determine whether or not sub-sampling of the biological communities e.g., mayflies, stoneflies, and caddisflies via the EPT Index, or other alternatives offers a viable method for gathering needed biological information.

The biomonitoring element consists of three phases to be implemented over a 3 to 4 year period. In the first phase, 24 macroinvertebrate samples from 18 DWGNRA locations will be collected and up to three sub-samples of 100 organisms identified to genus including Chironomidae larvae. Detailed analyses of the sub-samples (individual and collectively) will result in the selection of

sample analyses protocols i.e., number of organisms analyzed per sample and level of identification of Chironomidae. Following the establishment of these protocols, an additional 36 samples will be collected from DWGNRA locations and up to 60 samples from UDSRR locations (phase 2). Phases 1 and 2 will be conducted in 1995 and 1996.

Phases 1 and 2 will yield baseline macroinvertebrate data for the key tributaries to the Delaware River. This information and the habitat assessment information will be used to design a long-term biomonitoring/habitat assessment program for the Scenic Rivers Monitoring Program (phase 3) that will be implemented in 1997.

Besides the changes that might occur to the Scenic Rivers Monitoring Program's biological monitoring protocols as the result of the 1995-1996 study of biomonitoring techniques, a major change from the program's traditional methodology is the addition of habitat assessments at each biomonitoring site. Physical habitat is a major factor influencing biological communities and an evaluation of water column constituents and habitat structure at every site serves to supplement the biological data that is collected. Habitat assessment combined with measures of biological condition yield one of the following situations (adapted from Barbour and Stribling, 1991): 1) biological condition is as expected from habitat assessment, 2) biological condition is worse than expected from habitat assessment (potential toxic or organic pollution impacts), or 3) biological condition is better than expected from habitat assessment (potential organic enrichment).

To be effective, habitat assessments should examine those impacts anticipated from urbanization, including evaluations of substrate, channel, riparian, and bank characteristics, as well as natural attributes such as canopy, stream gradient, and aspect. Qualitative habitat assessment methods, such as EPA's Rapid Biological Protocols (RBP)(Plafkin et. al., 1989) have the advantages of requiring minimal time and providing a number to compare to the regional reference or "best attainable" site. This method has been used in the scenic rivers region by Monroe County (PA), Pike County (PA), and Pennsylvania Department of Environmental Resources. Quantitative methods, which can be time-intensive, have the advantage of providing unbiased quantitative measurements, from which change at a site can be more readily determined. More detailed discussion of the habitat assessment methods used in the scenic rivers region by various monitoring agencies is found in Proceedings of the Upper Delaware Water Quality and Biological Monitoring Conference, Report No. 17 of the DRBC/NPS Cooperative Monitoring Program.

Table 5 summarizes the habitat assessment protocol to be adopted for the Scenic Rivers Monitoring Program for tributaries. This includes the revised qualitative EPA RBP method, augmented by semi-quantitative and quantitative measurements for a number of habitat parameters where appropriate.

Tributary qualitative/quantitative assessments will be conducted once a year in late summer. Tributary study sites will be located at baseline monitoring sites (see Table 2), including a reach approximately 150 meters in length, at least half of which should be upstream of the macroinvertebrate/baseline site.

V.C.2 DELAWARE RIVER ECOSYSTEMS

As described previously, four study areas have been selected for the Delaware River ecosystem monitoring. These study areas will be studied annually for three years. The habitat method selected for tributaries cannot be directly applied to the river because the larger area precludes making accurate visual estimations for an entire reach. Therefore, only quantitative and semi-quantitative methods will be used for river Ecosystem Monitoring.

In the fall of 1994, each of the selected study areas were surveyed using GPS equipment. The survey consisted of the establishment of upstream and downstream boundary points, the establishment of intervening shoreline points, and the surveying of a longitudinal shoreline profile. This information has been entered into the DWGNRA GIS system in order to generate scale baseline maps.

The study area base maps will be used to locate 2 to 4 transects in each study area for a total of 4 to 6 transects when upstream and downstream boundary transects are included. These transects will be perpendicular to the direction of flow. In addition, shoreline zones approximating the maximal depth at which aquatic plants survive will be established along the length of the study area (or portions thereof if the area is extensive). The transects and the longitudinal shoreline zones will be the locations within each study area that are sampled and characterized repetitively. Once established, the transects and zones will be used for all subsequent surveys. GPS will be used to establish permanent transect markers. The longitudinal zones will vary slightly depending upon flow conditions.

The pool/run/riffle lateral transects and longitudinal zones will be characterized both physically and biologically as described in the following.

Physical Characteristics:

- Channel cross-sectional configurations: depth and bottom contours with velocity measured at each increment of length, width, or depth;

- Bottom substrate characteristics: cobble embeddness and pebble count for wadable depths and underwater video or photographic surveys for nonwadable depths at marked locations per unit of underwater width;

- Water column clarity: total suspended solids, turbidity, phytoplankton chlorophyll *a*, and Secchi depth;

- Bank and riparian zone characteristics: slopes, soils, stability, canopy etc.;

Table 5: Summary of Selected Habitat Assessment Parameters

EPA RBP Parameter #	Parameter	Measurement Type		
		Qualitative	Semi-Quantitative	Quantitative
1	instream cover (for fish)	X		
2	epifaunal substrate	X	X	
3	embeddedness	X	X	
5	velocity and depth	X		X
5	channel alteration	X		
6	sediment deposition	X		
7	frequency of riffles	X		X
8	channel flow status	X	X	
9	condition of banks	X		
10	bank vegetative protection	X		
11	grazing or other disruptive pressure	X		
12	riparian vegetative zone width	X		
	canopy angle			X
	stream gradient			X
	stream aspect (compass bearing)			X
	photodocumentation	photographs, slides, and/or video		

Biological Characteristics:

- Fish: acoustic counts per transect and spawning observations with electofish shocking available if desired; other fisheries work to be conducted by state and federal biologists if available;

- Macroinvertebrates: kick nets in riffle/run transects, basket or other artificial substrate samplers in pool transects, and leaf picking in macrophyte beds;

- Phytoplankton: chlorophyll *a*, primary productivity studies, and, as needed, plankton net tows or pours along transects;

- Periphyton: chlorophyll *a* and primary productivity studies as needed;

- Macrophytes: by species and bed density, establish habitat models that integrate physical and environmental requirements for plant growth and density;

- Mussels/shellfish: collect along transects and identify by species;

- Riparian vegetation: characterization and assessment

- Others as needed

The results of the first three years ecological monitoring activities will be transferred to other pool and run combinations, employing only those assessment methods that yield the required level of information concerning potential disturbances and impacts. For these and subsequent pool/run monitoring, sampling locations within each pool/run will likely be selected by randomization techniques based on a pool/run grid system developed from GPS/GIS data.

VI: SPECIAL STUDIES

VI.A INTRODUCTION

Any monitoring program requires a research or special investigations component to augment the formal monitoring design. These special studies provide information needed to answer questions raised from the monitoring program or to make the program more scientifically valid, efficient, or cost-effective.

There are various special studies that should be considered at this time for implementation over the next several years, or within the life span of the program design. In addition, the Scenic Rivers Monitoring Program should maintain an active interest in state-of-the-art and new water quality monitoring technologies and methods.

VI.B. POTENTIAL SPECIAL STUDIES

The following describes special studies and programs of current interest, or studies and programs which could conceivably be undertaken in the future as resources permit. Undoubtedly, other needs may arise as well.

- **Pollution Problem Surveys:** The analyses presented in Section VI.B.3.a -(Tributary Comparisons by Water Quality) suggests the need to investigate possible water quality problems in various tributary watersheds. Watersheds requiring investigation by the Scenic Rivers Monitoring Program or other entities include the following in priority order:

    - lower West Branch
    - Callicoon Creek
    - Delaware River from Port Jervis to Northern DWGNRA Boundary
    - Cherry Creek
    - Neversink River
    - Lackawaxen River
    - Vandermark Creek
    - Flatbrook
    - Shawnee Creek

- **Boundary Control Points:** One of the tasks emanating from the adoption of the Special Protection Waters regulations is the development of existing water quality definitions for Boundary Control Points (BCP), locations where a tributary or the Delaware River crosses a National Park Service designated boundary and becomes an Outstanding Basin Water. Information on the program's proposed statistical framework is presented in Section VII.G (Program Statistics). These statistics and data collected by the Scenic Rivers Monitoring Program will be used (among other activities) to develop Boundary Control Point definitions.

- **Priority Watersheds:** The Special Protection Waters regulations require that non-point source-oriented watershed plans be developed for selected watersheds. Establishing preliminary priority watersheds will be done as soon as possible (using some of the analyses herein) in order to implement data collection activities that might be needed for the subsequent watershed planning efforts.

- **Electronic/Automated Monitoring for Water Quality and Flow:** In spite of the mixed results with the 1993 Scenic Rivers Monitoring Program's study electronic monitoring, electronic water quality monitoring technology should be watched since the field is evolving. Reevaluation of the cost-effectiveness and efficacy of electronic, automatic monitoring equipment for baseline monitoring should be periodically evaluated.

- **Low Altitude Remote Sensing:** Aerial surveillance of selected river reaches using remote sensing techniques such as infrared and others have the potential for cost-effectively generating information that it difficult to obtain on-ground. The advantages, disadvantages, and long-term use of remote sensing as a monitoring technique capable of determining mixing and other characteristics of existing effluent plumes, sources of non-point pollution, impacts from National Park Service facilities, aquatic plant beds, water quality, and other information are being explored. A study was conducted in November 1994 on 50 miles of the Delaware River to examine the advantages of remote sensing. In 1995, several areas of potential problems will be investigated to ground-truth the remote sensing information.

- **Time of Travel and Mixing Zones:** Proposals for new wastewater discharges, the development of models, prioritization of watersheds, toxic spill planning, and other activities often require site-specific knowledge of mixing, travel times, and dispersion characteristics. The Scenic Rivers Monitoring Program should acquire the capability to perform these studies routinely as part of the Special Protection Waters program and related programs.

- **Sediment and Other Toxics:** The Scenic Rivers Monitoring Program conducted a major reconnaissance survey of sediment toxics in 1987. This survey should be repeated at regular intervals in order to determine trends and to identify new problems. Other toxic studies should also be considered as funding permits. Toxics analyses require funding for a contract laboratory.

- **National Park Service Activities including Agricultural Herbicides:** The DWGNRA is a major unit of the National Parks System and, as such, spends considerable public

funds for maintaining roads and facilities while developing new and expanding recreational facilities such as access areas, visitor centers, etc. The provision of new recreational facilities often requires significant earth disturbing activities and increased visitation to the new facility when completed.

The DWGNRA also owns significant amounts of agricultural lands which are leased to local farmers for agricultural planting. Because of the extensive agricultural use of DWGNRA lands, the recreation area is concerned about the impacts, if any, of herbicide use. A special study that assesses these impacts, possibly using new immuno-assay technology, should be explored.

- **Ground Water:** Studies to expand information concerning the interrelationship between ground water and surface water and its ramifications on water quality are required, particularly in the DWGNRA. Under differing hydrologic conditions, ground water enters the Delaware River or vice versa. As time permits, a limited routine ground water monitoring program should be established within the DWGNRA and special studies conducted as needed. These studies should focus on both the quality and quantity aspects of the ground water/surface water interface.

- **Delaware River Interagency Water Quality and Biological Survey:** In July and August 1974, the Pennsylvania Department of Environmental Resources and the New Jersey Department of Environmental Protection conducted an intensive water quality and aquatic biology survey of the Delaware River and Major tributaries between Hancock, New York and Trenton, New Jersey. A repeat of this study, now over 20 years old, would provide valuable information about water quality and biological changes over two decades plus new information. In addition, the study would provide an excellent opportunity for monitoring personnel from three states, the DRBC/NPS program, and various local and citizen programs to conduct a joint effort leading to increased interagency cooperation and sharing of expertise.

VII: OPERATING PROCEDURES

VII.A OPERATIONAL OBJECTIVES

Program operations consist of allocating resources, staffing, staff support, data management and use, quality assurance and control, internal and external relationships, and other factors. In order to realize the goals promulgated for the redesigned Scenic Rivers Monitoring Program, various operational objectives must be realized. The following lists the inter-related objectives established for the program.

VII.A.1. SHORT TERM OBJECTIVES

VII.A.1.a. Expand the permanent, professional staffing base.

Experience with the program over the last ten years has indicated limitations with the past reliance on full-time, temporary staff and seasonal staff. In all respects, the program has been operating at least 25% over its logical capacity, the success of the program in performing special studies and accomplishing other monitoring tasks being largely due to extra efforts that can not be sustained.

Reliance on seasonal and other non-permanent staff limits the program's ability to perform needed special studies and more sophisticated biological monitoring, places additional burdens and responsibilities on the professional DRBC staff, and limits the program's overall abilities in many ways. Use of seasonal staff for field work (without professional staff on-site), in particular, reduces the program's ability to monitor multiple seasons and results in supervision problems. Permanent professional water quality staff at the UDSRR and the DWGNRA are needed to professionalize the program. These staff would work with DRBC staff throughout the year on the expanded program. Among the needed staff is a professional biologist, particularly experienced in macroinvertebrate and aquatic plant taxonomy.

(This short-term objective was accomplished in 1994 with each National Park Service unit acquiring permanent employees for the program.)

VII.A.1.b. Reduce the use of the NPS water laboratory and/or private laboratories.

The National Park Service as part of the Scenic Rivers Monitoring Program operates a small water quality laboratory in the DWGNRA. Fecal bacteria are run routinely in the laboratory, but the lab has some capabilities beyond bacterial analyses i.e., water chemistry. Due to the limitations regarding the laboratory (particularly staffing), the Scenic Rivers Monitoring Program has relied, to a large extent, on private laboratories for specialized analyses including nutrients.

Since funds for private laboratory analyses will be limited in the foreseeable future, a key question is what capacities the laboratory should have. Three alternatives exist for the laboratory:

(1) expand its capabilities by hiring professional laboratory personnel and purchasing equipment; (2) continue to rely on private laboratories; and (3) replace the laboratory's potential functions with colorimetric and similar kits. Expanding the lab's capabilities would be the most expensive alternative because of staff and operating costs, especially when occupational health and safety concerns are factored in.

Therefore the only feasible alternative is Alternative 3, except when special funding (grant, special appropriation etc.) is available.

VII.A.1.c. Obtain stable funding for a limited amount of specialized (i.e., non-routine) environmental analyses.

A need for specialized analytical capabilities of the program will always be needed. This objective asks that funds be routinely budgeted for discretionary analyses or for special needs.

VII.A.1.d. Expand current monitoring activities from a five-month sampling season to a 9 to 10 month season with limited winter-time monitoring at one or more river locations.

The current program generally operates from May through September. Expanding the program to a annual basis will provide information on non-point sources, biological phenomena, and other seasonal factors. (Winter sampling may be restricted for safety and access reasons.)

VII.A.1.e. Implement full-scale ecosystem monitoring program.

An ecosystem monitoring program represents an expanded, integrated biological monitoring program that directly addresses ecosystem health. The development and implementation of an ecosystem monitoring program is viewed as a possible strategy for acquiring better environmental information more cost-effectively.

VII.A.1.f Modernize data collection and management by expanding GIS and GPS use.

Geographic Information Systems (GIS) represent modern technology whereby data can be managed and linked to computer-generated map layers for both assessment and planning purposes. Assisting in the precision of GIS are Global Position Systems that can precisely locate sampling sites through interface with satellite systems circling the earth. The Scenic Rivers Monitoring Program, through the DWGNRA GIS lab, will expand the use of GIS and GPS in the implementation of the re-designed program. Use of GIS and GPS for both baseline and ecological monitoring will add a new dimension to the DRBC/NPS cooperative monitoring program.

VII.A.2 LONG-TERM OBJECTIVES

Long term objectives represent operational activities that could be undertaken in the future if funding and a need for the activity were available. These objectives are not recommended for implementation at this time.

VII.A.2.a. Obtain a full-time program administrator.

The recommended organizational structure relies on co-managers who have other major program responsibilities. Should the program be significantly expanded in the future, hiring of a program manager would be desirable in order to increase the amount of available staff time that can be devoted to program design and administrative tasks, data interpretation and reporting, data management and other time-consuming program responsibilities.

VII.A.2.b. Establish a water quality monitoring outreach program.

The purpose of this program would be to provide support to existing local governmental and citizen monitoring programs operating in the drainage area and to get new ones operating. A second purpose of the outreach program is to provide increased support for researchers conducting investigations in the DWGNRA and UDSRR.

VII.A.2.c. Establish a permanent Scenic Rivers Regional Water Quality Monitoring Coordinating Committee.

The current program holds periodic water monitoring conferences. A permanent committee, meeting once or twice per year, would possibly be a more effective coordinating mechanism.

VII.A.2.d Add automatic flow monitoring capabilities to key tributaries.

Continuous, automatic flow monitoring provides useful data for evaluating the impacts of stormwater, snowmelt and other hydrologic events. As needs and funding permit, a program of expanding the existing continuous flow monitoring network should be considered, particularly for watersheds selected under the Watershed Prioritization required by the Special Protection Waters regulations.

VII.B PROPOSED STAFF REORGANIZATION

The Scenic Rivers Monitoring Program has historically relied on temporary and seasonal DRBC and NPS employees to do the bulk of the field and various other duties with DRBC professional staff engaged in program management and other responsibilities. The existing organization structure was described previously (see Figure 6). A new organization structure is proposed in order to: (1) decrease dramatically the program's reliance on temporary and seasonal employees; and (2) decrease the program's reliance on DRBC professional staff as the program manager.

The professionalization of the program means that the program will no longer rely on temporary and seasonal staff to perform the bulk of the program's monitoring and special studies responsibilities. Temporary and seasonal staff will continue to be used only when available or needed, but only as assistants to the professional staff, e.g., seasonal staff might accompany professional staff into the field, but would work only under their direct supervision.

Two organizational charts are presented. Figure 5 presents the organization of responsibilities between agencies while Figure 6 shows a detailed staff structure integrated with all Special Protection Waters activities. The proposed organizational structure will continue to rely on

Figure 5: Relationship of Program Partners

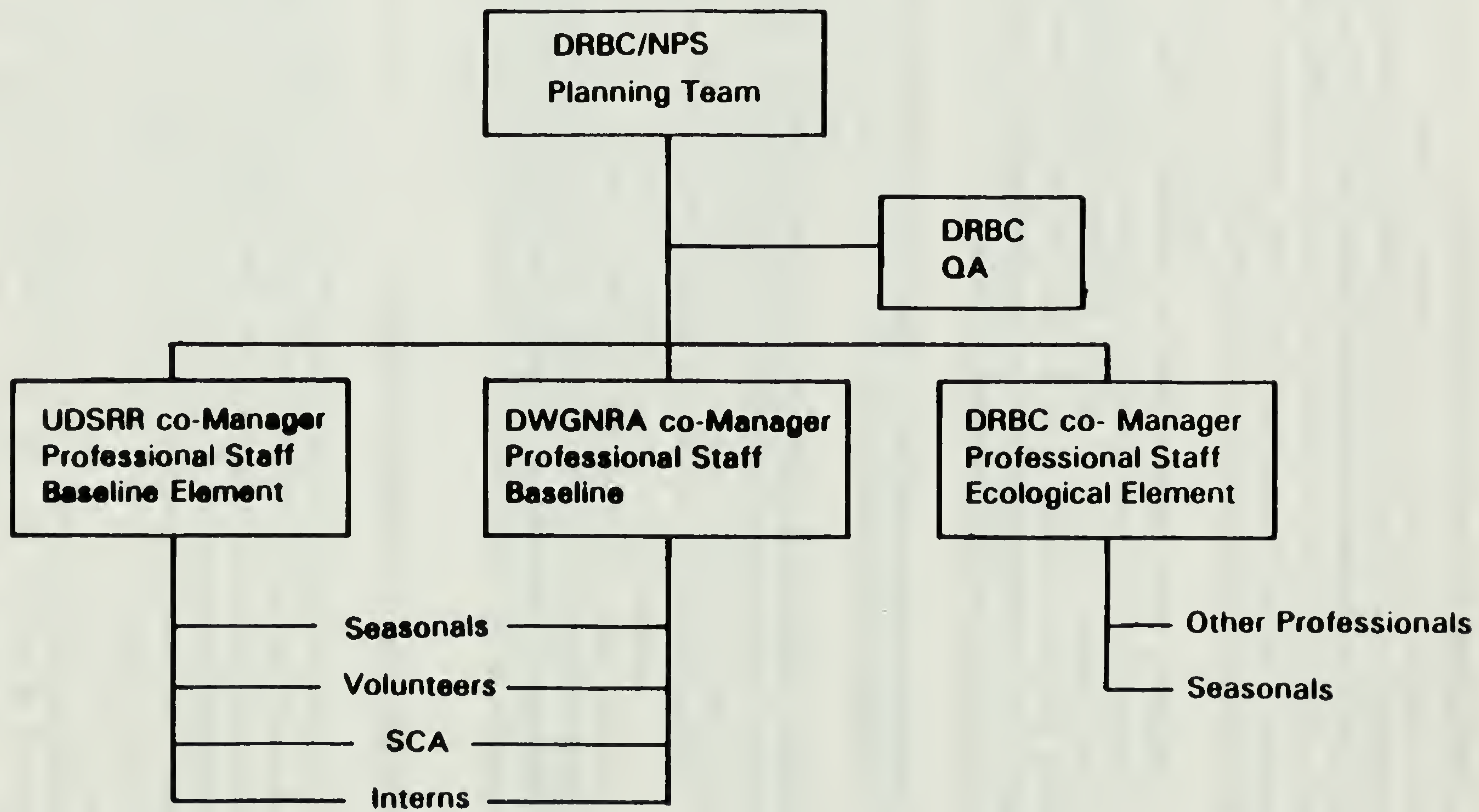


Figure 6: Integration of Program Staff by Function

A. STAFF AVAILABLE FOR SPECIAL PROTECTION WATERS ACTIVITIES[1]

DRBC	DWGNRA	UDSRR	COOPERATORS
1. Supervising Engineer	7. Chief, Biologist	19. Resource Manager	23. Academy of Natural Sciences
2. Water Resources Planner	8. Aquatic Ecologist	20. Biologist	24. North Carolina State University
3. Water Resources Engineer	9. Aquatic Biologist	21. Temporary Help	25. Others
4. Environmental Scientist	10. Terrestrial Biologist	22. Other UDSRR	
5. GIS Specialist	11. Community Planner		
6. Project Review Branch	12. Water Resources Planner		
	13. GIS Specialist		
	14. GIS Specialist		
	15. Biological Technician		
	16. River District Rangers		
	17. Temporary help		
	18. Other DWGNRA		

B. SPECIAL PROTECTION WATERS ACTIVITIES AND STAFF DISTRIBUTION

Overall Management	Monitoring Element	Modeling Element	Information Management	Planning Element	Project Review Element
(1,7,19)	**Baseline Monitoring** (9,15,17,20) **Bio/habitat Monitoring** (4,8,9,10,15,17,20, 21,23) **Special Studies** (*) **Ecosystem Monitoring** (1-3,4*,8,9*,10*, 15,16,20*)	**River Modeling** (2-5) **Watershed Modeling** (3,5,13,14,24)	**Storet** (2,5) **GIS** (2,5,13,14,20) **Information Processing** (1-5,8,9,20)	**DEWA WRP** (1,12) **Prioritization** (1-4) **Watershed** (1-4,12)	**DRBC** (6) **National Park Service** (7,11,12,19)

* As needed

POTENTIAL as of 2/95

1 Staff shown on the chart do not work exclusively on Special Protection Waters Activities.

overall planning by a DRBC/NPS Planning Team with DRBC water quality staff serving as the technical advisor to the team. DRBC staff also will serve as the program's quality assurance staff. The quality assurance officer will be independent of the program's chain-of-command, reporting to it when problems are noted.

The major change will be a division of responsibilities formerly performed by the DRBC Program Manager and the DWGNRA Assistant Program Manager. The Program Manager's position will be shared with DRBC, the UDSRR, and the DWGNRA. Each of the three participating agencies will provide a co-manager to the program.

A Co-Manager will:

- Maintain an inventory on his/her portion of the total program supplies and equipment

- Correct problems noted by the Quality Assurance Officer

- Coordinate activities with the other co-managers (e.g., assuring that staff from each participating agency is available to the other agencies when needed to perform joint activities)

- Arrange the training of seasonal staff when needed

- Insure that data are entered into the program's data management system in a timely fashion and that it is performed correctly (with oversight responsibilities by the Quality Assurance Officer)

- Maintain up-to-date listings of the status of his/her portion of the total program with monthly reports submitted to the planning team members

- Develop assessments of the available funding from his/her agency prior to each year's activities and maintain a running total on expenditures

- Coordinate all funding requests with the other co-managers and insure that each entity solicits funding from applicable sources in support of the program

- Review all program data at regular intervals for possible follow-up surveys

- Coordinate the program with other monitoring entities (providing technical assistance, requesting technical assistance and other coordinating activities)

- Suggest, research, and help design special studies and programs

- Participate in the planning of the program by suggesting modifications to operating procedures, new methods and techniques, and other changes to the program

- National Park Service Co-Managers will be responsible for the Baseline

Monitoring Element in their NPS unit with the DWGNRA Co-Manager's responsibilities also including the Millrift to Northern DWGNRA Boundary reach

- The DRBC Co-Manager will responsible for the Ecosystem Monitoring Element and special studies with staff and resources contributed by the DWGNRA and UDSRR

In practice, the Co-Managers and other staff of the three participating agencies will work cooperatively. For example, the two NPS Co-Managers might work together occasionally, and each would be expected to participate with DRBC staff on Ecosystem Monitoring activities in their area. At other times, the two NPS Co-Managers would work independently with their seasonal staff in the collection of baseline monitoring data.

Over time, it is envisioned that the various professional staff might develop special expertise or interests. In this case, overlapping responsibilities could be developed whereby duties are delegated by expertise rather than by NPS unit or monitoring program element in order to obtain the best possible data and program efficiency.

Overall responsibility for preparing the program's annual report will be retained by DRBC staff, but NPS participants will be responsible for preparing the report sections dealing with the Baseline Monitoring in their area of responsibility and for providing GIS services for mapping (and possibly data management).

VII.B.3 SUMMARY OF AGENCY RESPONSIBILITIES

VII.B.3.a National Park Service

- Participate in the program's Planning Committee
- Provide professional staff to the program
- Perform Baseline Monitoring within each unit's area
- Provide funding support for the Scenic Rivers Monitoring Program (budget funds for the program and its staff, seek other sources of funding cooperatively with the other program participants, etc.)
- Assist the other participating agencies in Baseline Monitoring, Ecological Monitoring, and special studies as needed
- Provide GIS services to the program, as needed
- Provide a Program Co-Manager
- Assist in preparation, publishing, and distribution of the biennial program report

VII.B.3.b. Delaware River Basin Commission

- Participate in the program's Planning Committee
- Provide planning services to the Planning Committee
- Provide the program's Quality Assurance Officer and one Co-Manager
- Provide professional staff to the program
- Perform the program's Ecological Monitoring Element and special studies
- Provide technical assistance for data management and enter data into STORET and BIOS or their equivalent
- Provide funding support for the Scenic Rivers Monitoring Program (budget funds for the program and its staff, seek other sources of funding cooperatively with the other program participants, etc.)
- Assist the other participating agencies in Baseline Monitoring as needed
- Coordinate the preparation of the biennial program report and assist in its preparation, publication, and distribution

VII.B.3.c Program Administrator

The proposed program relies on existing DRBC and NPS staff, assuming currently proposed NPS positions are filled. This level of staffing is adequate for the program as currently envisioned.

If unanticipated sources of permanent funding become available for program expansion, however, additional technical and scientific staff may be required. The report, A Proposal for Long-Term Ecological Monitoring, DWGNRA (DWGNRA, 1993) describes the level and type of staff needed for a major expansion. If any major expansion of the program occurs, a full-time program administrator will be required to provide the overall staff supervision, administrative, management, and planning duties that are outlined in the currently-recommended program.

VII.C SAMPLE ANALYSES

The reliance of the program on the existing DWGNRA laboratory will be reduced. Use of the laboratory by UDSRR staff necessitates substantially increased travel times with associated problems with the holding times of bacterial samples. The future move of the DWGNRA resource management division from its current location to one that is even further removed from the UDSRR is an additional consideration. Reliance on a laboratory location with an uncertain future is not wise for the initiation of a newly designed water quality monitoring program. Lastly, concentrating laboratory equipment, supplies, and expertise at one location over a 120 mile reach of the Delaware River reduces the program's flexibility and efficiency.

Since it is recommended that the DWGNRA laboratory capabilities not be expanded, the lab should be retained solely for use by the DWGNRA plus use as a biological laboratory and for applicable special studies. Incidental use of the DWGNRA lab by DRBC staff and occasionally by staff from all three participating agencies (for a large joint study, for example) is envisioned as well.

Since the recommended program proposes to rely on commercially-available water testing kits for much of its water chemistry analyses, a satellite water lab was created in 1994 in the UDSRR for bacterial analyses. The two program laboratories, however, should not be viewed as independent laboratories. Equipment and supplies will continue to be pooled between all the agencies, identical test methodologies will be used, and both laboratories will be governed by the same quality assurance plan. In addition, the program's Quality Assurance Officer will establish protocols for regular testing of quality control between the two labs.

VII.D DATA MANAGEMENT

Data management consists of entering routine water quality data into a computer from field and laboratory sheets. Using data management software, the data are subsequently downloaded to the EPA STORET system for storage. Macroinvertebrate data are entered into BIOS, the biological element of STORET. Improvements to the current system are warranted and modifications will be suggested by DRBC. For both the baseline and ecosystem monitoring elements, full use of GIS capabilities for data management is envisioned. Water quality data collected as part of the ecosystem monitoring element and special studies will be entered into STORET on a selective basis rather than routinely. Entering these types of data into STORET causes problems due to their specialized nature. A data base, however, will be established for the ecological monitoring element using GIS and applicable software.

VII.E QUALITY CONTROL/QUALITY ASSURANCE

A quality assurance plan will be prepared annually and submitted to EPA for approval. Based on comments received from EPA plus new information derived from the operation of the program and the scientific literature, quality assurance procedures will be refined over time when needed. These refinements will appear in the program quality assurance plan.

Modifications in the program's organization structure as described in Section VII.B is intended to increase quality control by increasing the level of professional involvement in the program and by relieving DRBC staff of some of their past program responsibilities so that increased attention can be given to the Quality Assurance Officer's duties.

VII.F REPORTING PROCESS

The Scenic Rivers Monitoring Program has, since its inception, published annual reports in a numbered series. The annual preparation of a report fit into the program's schedule because the program was a four-month, intensive sampling effort. However, in recent years the quality of the program report has suffered because of the lack of DRBC staff time to develop a thorough analyses of data.

The redesigned program differs from the past program in that it will be an annual (9 to 10 months or ice-free months) sampling program with less baseline data collected and a large multi-year component (i.e., the ecosystem element). It is recommended, therefore, that the redesigned program continue the report series of the past program (i.e., be numbered in the same sequence etc.), but that the report's frequency be reduced. The following reporting protocol is recommended:

- Transitional: Memo report to management with summary of program activities, necessary adjustments as a result of the 1994 trial program, and synopsis of major and unusual findings; scheduled for early Spring 1995;

- Annual: Memo report to management with summary of program activities and synopsis of major and unusual findings, scheduled for Spring 1996 and every other even-numbered year thereafter;

- Biennial: Report with summary of program activities, discussions of major and unusual findings, and data analyses for both the baseline and ecosystem elements; Prepared in Spring 1997 and every other odd-numbered year thereafter;

- Periodic: Reports on special studies after data are analyzed.

Reports prepared hereafter will be published in the name of all the participants rather than in DRBC's name with the "in cooperation with the National Park Service" statement.

VII.G PROGRAM STATISTICS

VII.G.1 Statistics to Determine Number of Data Required for Special Protection Waters Regulations

VII.G.1a Statistical Procedure

For the Special Protection Waters regulations, it is necessary to define the sample size required for determining if existing water quality is measurably changing. The following method was developed for comparing sampling data to the regulatory criteria:

- Determine original data set distribution.

- Simulate the original distribution.

- Randomize sampling from the simulated distribution to represent natural variation.

- Determine the size requirement of future data sets, by using the simulated distribution, to accurately determine differences between the original and future data sets.

Frequency distributions were determined for several of the original data sets from the Upper and Middle Delaware SRR that represent "existing water quality." The data sets selected for evaluation from the Middle Delaware were fecal coliform (seasonal), total phosphorus (annual), NO_2+NO_3 (annual and seasonal), NH_3+NH_4 (annual and seasonal), and BOD_5 (seasonal). Data sets evaluated from the Upper Delaware were fecal coliform (seasonal), total phosphorus (annual), NO_2+NO_3 (seasonal), NH_3+NH_4 (annual and seasonal), and BOD_5 (seasonal).

Each data distribution was divided into 10 segments with each segment representing 10% of the data. The actual data values associated with the extremes of each 10% range were used to represent the distribution pattern. This segmenting is similar to that used for Monte Carlo (Benjamin and Cornell, 1970) simulations. A 2-tailed 95% confidence interval was calculated for the data set to eliminate potential bias from mechanical, environmental, and human error that may have positioned outliers in the tails of the distribution. The 95% confidence limits were used as the minimum and maximum values of the distribution. In all cases, the 95% confidence limits included the 10 and 90 percentile values used in the current regulations.

Data groupings of 10, 20, 50, 70, 140, and 200, representing the number of samplings from a given water quality parameter distribution, were evaluated. Every sampling from each data grouping was randomized to select any 10% segment of the distribution and any value within the 10% segment range. Data from the "10" set were also used in the "20" set and data from the "20" set were also used in the "50" set, etc.. The overlapped portion between data groupings provided a cumulative evaluation of the same data in all combinations.

One-thousand iterations were performed on the data groupings to stabilize the distribution patterns for accurate comparisons. Geometric averages were calculated for each iteration. Minimum, maximum, average, standard deviation, and 2-tailed 95% confidence intervals were calculated for the 1,000 geometric averages for each grouping.

Evaluation of the extent to which the different data groupings represented the original data set was performed by comparing the range between the original data set's upper 95% confidence limit about the mean and geometric average (equivalent confidence limit), to the range of each data grouping's upper 95% confidence limit about the data set and average. "Z" statistic values were calculated to perform this comparison. A "Z" value of 1.96 is required for determining 2-tailed, 95% confidence limits for either the average value or the entire data set.

$$Z = \frac{\text{Log (Upper 95\% C.L.)}_{\text{New}} - \text{Log (Average)}_{\text{New}}}{\text{Log (Standard Deviation)}_{\text{Original}}} \times \sqrt{N - 1}$$

C.L. = Confidence Limit
N = Number of samples in original distribution

The "Z" value is then compared to a "Z" table, representing a 2-tailed test, to obtain a probability value. The probability value represents the confidence limit of either the data set or the average of the data set, depending upon its use.

Distributions were considered equivalent when the upper 95% confidence limit of the simulated data was equal to or less than that of the original data set. When simulated data sets required more than 200 data to satisfy the range of the upper 95% confidence limit, extrapolation by regression was used to determine the actual number of data.

Although upper 95% confidence limits were analyzed for data set comparisons, lower 95% confidence limits will be used for those parameters having standards lower than the average. Dissolved oxygen is one such parameter.

VII.G.1b Results

Table B1 in Appendix B contains the following results for each parameter within the Middle Delaware Scenic and Recreational River: number of samplings simulated in each data grouping, average, standard deviation, and lower and upper 95% confidence limits of the data sets after 1,000 iterations. The table also presents the number of samples and equivalent upper confidence limit of the original distribution, and the number of data in subsequent samplings required for comparison to this confidence limit. The geometric averages of comparison (i.e., future) and original data sets are used for these statistical comparisons. Table B2 presents these same results for each parameter evaluated within the UDSRR.

The results show that the number of data in future data sets required for comparison to the original data set is mainly dependent upon 3 factors: 1) The size (number of data) in the original data set; 2) the skewness of the original data set; and 3) the proximity of the data to their limit of detection. The larger a data set, the more continuous is its distribution, allowing fewer and smaller voids, producing less data variability. Skewness of a data set increases variability due to the elongated tail(s) of the distribution. Skewness also shifts the average (point of central tendency) value in a distribution to a location in the direction of the most elongated tail. When data are in close proximity to their limit of detection, the limit of detection restricts the distribution pattern from spreading beyond that point, thus limiting variability to only the unrestricted side of the distribution. Therefore, if the original data set contains a large number of values and/or the values are close to the limit of detection, the required size of a comparison data set will be relatively large. However, if the original data set contains a limited number of values and/or the distribution is skewed, the required size of a comparison data set will be relatively smaller.

Seasonal parameters for the MDSRR show the number of samples required for comparison to the original data set to range from 161 (BOD_5) to 289 (fecal coliform). Parameters for annual water quality criteria require from 160 (total phosphorus) to 302 (NH_3+NH_4) samples for comparison to the original data set.

Results for the UDSRR show data set size ranges from 57 (NO_2+NO_3) to 258 (fecal coliform) for seasonal criteria and from 119 (total phosphorus) to 127 (NH_3+NH_4) for annual criteria comparisons to the original data set.

VII.G.1c Recommendations

Although the number of samples required to compare data sets is determined by the above

statistical procedure, the distribution of data from data sets containing 140 to 200 values does not change significantly. Therefore, a reasonable data set for use in evaluating Special Protection Waters criteria is one that contains at least 200 data. Table 6 presents the estimated number of years to acquire the needed data. For many parameters, these data have largely been acquired. Once the initial set of data is acquired, evaluations of Special Protection Waters compliance can be conducted annually with the most recent year's data added to the data set and the oldest year's data deleted, if desired.

Additional parameters that are being considered for water quality standards should contain enough data to provide a valid target for determining changes in water quality. Results of the above statistical method show that the difference in variability, within all data sets, was minimal between 140 and 200 samples. Therefore, to maintain confidence in data set comparisons, a minimum of 180 samples is recommended for the establishment of additional water quality criteria.

Table 6: Number of Years of Data to Assess Existing Water Quality and Measurable Change[5]

SPW Criteria Type	# Sites	# Months	Sites/Year	# Samples Required	Required Time to Gain Minimum Samples[6]
UPPER DELAWARE SCENIC AND RECREATIONAL RIVER (INCLUDING PORT JERVIS)					
ANNUAL	8	10	80	200	3 yrs.
SEASONAL (May - Sept)	8	5	40	200	6 yrs.
MIDDLE DELAWARE SCENIC AND RECREATIONAL RIVER & REACH BETWEEN SCENIC RIVERS					
ANNUAL	8	10	70	200	3 yrs.
SEASONAL (May - Sept)	7	5	35	200	6 yrs.
UPPER AND MIDDLE DELAWARE TRIBUTARIES SAMPLES REQUIRED TO DEVELOP SPW CRITERIA AND TO SUBSEQUENTLY COMPARE TO CRITERIA					
ANNUAL	8	10	80	200	3 yrs.
SAMPLES REQUIRED FOR ADDITIONAL RIVER SPW CRITERIA					
ANNUAL	UDSRR 8	10	80	180	2 yrs.
	DWGNRA 7	10	70	180	3 yrs.
SEASONAL (May - Sept)	UDSRR 8	5	40	180	5 yrs.
	DWGNRA 7	5	35	180	6 yrs.

[5] When samples are collected at selected sites (see Table 2).

[6] Rounded to nearest year.

VII.G.2 Reporting Statistics

In addition to using the statistics described above, the redesigned Scenic Rivers Monitoring Program will use various statistical and graphical methods for reporting purposes. Box and Whisker Plots, linear and other regression techniques, running averages, and other methods will be used as required. The selection of appropriate statistical methods will, in general, be dependent on the type of data collected as well as the analytical need i.e., the answers sought. The results of statistical analyses will be presented in the program reports.

VII.H INTERAGENCY RELATIONSHIPS INCLUDING CITIZEN MONITORING PROGRAMS

VII.H.1 External Relationships

The redesign of the Scenic Rivers Monitoring Program proposes nothing new for external interagency or interorganizational relationships. In the past, the program has relied on personal contacts, periodic water quality monitoring conferences, and periodic meetings to affect regional coordination. While it might be advantageous for all monitoring entities in the scenic rivers region to formalize their interagency relationships by forming a coordinating committee or by merging monitoring programs into a multi-agency, or multi-agency/citizen organization program, no initiatives to formalize relationships with other programs will be undertaken by the Scenic Rivers Monitoring Program unless expressly requested by the organization desiring to formalize a relationship with the DRBC/NPS program.

If interest is shown by another monitoring program for integrating program operations with the Scenic Rivers Monitoring Program, such proposals would be considered favorably. Similarly, the Scenic Rivers Monitoring Program stands ready to assist any other monitoring program in the region in activities which they might be planning and for which staff and other assistance is needed.

At various times in the past, members of the DRBC/NPS planning team have been queried about the participation of individual citizens in the DRBC/NPS program, or the development of a citizens monitoring program as an adjunct to the Scenic Rivers Monitoring Program. The following policies are recommended concerning these issues:

- Individual citizens wishing to participate in the program can do so by volunteering under the NPS Volunteers in Parks Program. Citizen volunteers will work under supervision of the Co-Manager for either the UDSRR or the DWGNRA, performing duties similar in nature to seasonal or Student Conservation Association staff. In addition, citizens will be informed about citizen monitoring programs operating in the scenic rivers area since participation in those programs may, in many cases, be more desirable to the individual.

- Major goals of the program redesign are to increase the professional level of the program's major participants, to optimize data collection efforts, to decrease the expenditure of resources, and to reduce the program management load. The program, therefore, has no interest in establishing any citizen monitoring programs since several

independent organizations already exist.

- The program will coordinate its efforts with the efforts of citizen monitoring programs and the program's staff will provide technical guidance and assistance as requested.

- Scenic Rivers Monitoring Program staff will establish, for any citizen monitoring program, tributary flow monitoring capabilities for all sites monitored by the program that are located within, or near the UDSRR and DWGNRA National Park Service boundaries.

VII.H.2 Internal Relationships

The preparation and execution of an interagency Memorandum of Agreement between the Delaware River Basin Commission, the Upper Delaware Scenic and Recreational River, and the Delaware Water Gap National Recreation Area is recommended.

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Appendix A:

List of Reports Published by the Scenic Rivers Monitoring Program

REPORTS PUBLISHED BY THE SCENIC RIVERS MONITORING PROGRAM

UPPER DELAWARE SUMMER LIMNOLOGICAL PROGRAM, 1969-1979: BACKGROUND, WATER CHEMISTRY DATA AND MACROINVERTEBRATE DATA (February 1980).

REPORT NO. 2: PRIMARY PRODUCTIVITY OF THE NON-TIDAL DELAWARE RIVER, JULY AND AUGUST 1980 (June 1981).

REPORT NO. 3: WATER QUALITY OF THE UPPER DELAWARE SCENIC AND RECREATIONAL RIVER, 1981 SURVEY (September 1981).

REPORT NO. 4: ANALYSIS OF PHYTOPLANKTON DATA IN THE NON-TIDAL DELAWARE RIVER 1969-1979 (December 1982).

REPORT NO. 5: DELAWARE RIVER WATER QUALITY IN THE DELAWARE WATER GAP NATIONAL RECREATION AREA (February 1983).

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REPORT NO. 10: FINDINGS OF THE 1987 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM INCLUDING THE SPECIAL SEDIMENT TOXICS SURVEY (March 1988).

PROCEEDINGS OF THE MARCH 8, 1988 SCENIC RIVERS WATER QUALITY WORKSHOP (September 1988).

REPORT NO. 11: FINDINGS OF THE 1988 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM INCLUDING SPECIAL DWGNRA STUDIES (April 1989).

RECOMMENDED BIOLOGICAL CRITERIA FOR THE MIDDLE DELAWARE SCENIC AND RECREATIONAL RIVER (January 1990).

REPORT NO. 12: FINDINGS OF THE 1989 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM (April 1990).

REPORT NO. 13: FINDINGS OF THE 1990 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM (April 1991).

REPORT NO. 14: FINDINGS OF THE 1991 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM (March 1992).

REPORT NO. 15: FINDINGS OF THE 1992 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM (March 1993).

REPORT NO. 16: FINDINGS OF THE 1993 SCENIC RIVERS WATER QUALITY MONITORING PROGRAM AND STREAM FLOW RATING CURVES FOR SEVENTEEN TRIBUTARIES (May 1994).

REPORT NO. 17: PROCEEDINGS OF THE UPPER DELAWARE WATER QUALITY AND BIOLOGICAL MONITORING CONFERENCE (December 1994).

REPORT NO. 18: REDESIGN OF THE DRBC/NPS SCENIC RIVERS MONITORING PROGRAM (December 1994).

Appendix B:

Statistical Results from the Middle and Upper Delaware Scenic and Recreational Rivers Data Distribution Analyses

Statistical Results for the Middle Delaware Scenic and Recreational River								
Parameter	No. of Simulated Samples	Results of 1,000 Iterations				Original data set		No. samples required for data set comparisons
		Average	Standard Dev.	Lower 95% C.L.	Upper 95% C.L.	No. of samples	Equivalent Upper C.L.	
Fecal Coli (Seasonal)	10	51.89	21.56	9.63	94.15	493	100	289
	20	49.65	14.33	21.56	77.74		100	
	50	48.49	8.83	31.18	65.80		100	
	70	48.35	7.19	34.26	62.44		100	
	140	47.82	5.20	37.63	58.01		100	
	200	47.75	4.29	39.34	56.16		99.4	
NO_2+NO_3 (Seasonal)	10	0.222	0.041	0.141	0.303	493	100	200
	70	0.220	0.029	0.164	0.276		100	
	50	0.219	0.098	0.184	0.254		100	
	70	0.219	0.015	0.190	0.249		100	
	140	0.219	0.010	0.198	0.239		97.6	
	200	0.219	0.090	0.201	0.236		95.0	
BOD5 (Seasonal)	10	0.615	0.129	0.362	0.868	188	100	161
	20	0.608	0.090	0.432	0.784		100	
	50	0.604	0.056	0.495	0.713		100	
	70	0.603	0.048	0.510	0.697		99.6	
	140	0.603	0.033	0.538	0.668		96.2	
	200	0.602	0.027	0.549	0.656		91.6	
NH_3+NH_4 (Seasonal)	10	0.023	0.002	0.010	0.036	235	100	186
	20	0.023	0.005	0.013	0.032		100	
	50	0.022	0.003	0.016	0.028		100	
	70	0.022	0.002	0.017	0.027		99.8	
	140	0.022	0.09[illegible]	0.019	0.025		97.5	
	200	0.022	0.001	0.019	0.025		93.9	

Table B1. (Cont.)

Statistical Results for the Middle Delaware Scenic and Recreational River								
Parameter	No. of Simulated Samples	Results of 1,000 Iterations				Original data set		No. samples required for data set comparisons
		Average	Standard Dev.	Lower 95% C.L.	Upper 95% C.L.	No. of samples	Equivalent Upper C.L.	
NO_2+NO_3 (Annual)	10	0.257	0.036	0.186	0.328	555	100	216
	20	0.256	0.026	0.206	0.305		100	
	50	0.255	0.016	0.224	0.285		100	
	70	0.255	0.014	0.228	0.282		100	
	140	0.254	0.010	0.236	0.273		98.9	
	200	0.254	0.008	0.239	0.270		96.2	
NH_3+NH_4 (Annual)	10	0.041	0.014	0.013	0.068	657	100	302
	20	0.039	0.010	0.020	0.059		100	
	50	0.039	0.006	0.026	0.051		100	
	20	0.038	0.005	0.028	0.048		100	
	140	0.038	0.004	0.031	0.045		100	
	200	0.038	0.003	0.032	0.044		100	
Total Phosphorus (Annual)	10	0.027	0.003	0.020	0.034	252	100	160
	20	0.027	0.002	0.022	0.032		100	
	50	0.027	0.002	0.024	0.030		100	
	70	0.027	0.001	0.024	0.029		99.6	
	140	0.027	0.001	0.025	0.028		95.8	
	200	0.027	0.001	0.025	0.028		93.0	

Statistical Results for the Upper Delaware Scenic and Recreational River

Parameter	No. of Simulated Samples	Results of 1,000 Iterations: Average	Standard Dev.	Lower 95% C.L.	Upper 95% C.L.	Original data set: No. of samples	Equivalent Upper C.L.	No. samples required for data set comparisons
Fecal Coli (Seasonal)	10	28.90	13.69	2.07	55.74	443	100	258
	20	27.32	8.83	10.01	44.64		100	
	50	26.51	5.26	16.20	36.82		100	
	70	26.48	4.45	17.75	35.20		100	
	140	26.23	3.10	20.16	32.31		99.6	
	200	26.17	2.54	21.20	31.15		98.4	
NO_2+NO_3 (Seasonal)	10	0.309	0.054	0.204	0.414	72	100	57
	20	0.307	0.038	0.232	0.382		100	
	50	0.306	0.024	0.258	0.353		96.1	
	70	0.306	0.020	0.266	0.345		92.0	
	140	0.305	0.015	0.276	0.334		80.3	
	200	0.305	0.012	0.281	0.328		71.1	
BOD5 (Seasonal)	10	0.665	0.132	0.406	0.923	72	100	64
	20	0.658	0.094	0.473	0.843		100	
	50	0.654	0.061	0.537	0.771		97.1	
	70	0.652	0.050	0.554	0.751		93.7	
	140	0.658	0.035	0.584	0.722		81.3	
	200	0.658	0.029	0.596	0.709		72.9	
NH_3+NH_4 (Seasonal)	10	0.015	0.003	0.009	0.021	72	100	63
	10	0.015	0.002	0.010	0.019		100	
	50	0.015	0.001	0.012	0.017		96.5	
	70	0.015	0.001	0.012	0.017		93.0	
	140	0.015	0.001	0.013	0.016		82.0	
	200	0.015	0.001	0.013	0.016		76.2	

Table B2. (Cont.)

Statistical Results for the Upper Delaware Scenic and Recreational River								
Parameter	No. of Simulated Samples	Results of 1,000 Iterations				Original data set		No. samples required for data set comparisons
		Average	Standard Dev.	Lower 95% C.L.	Upper 95% C.L.	No. of samples	Equivalent Upper C.L.	
NH_3+NH_4 (Annual)	10	0.022	0.005	0.011	0.032	154	100	127
	20	0.022	0.004	0.014	0.028		100	
	50	0.021	0.002	0.016	0.026		100	
	70	0.021	0.002	0.017	0.025		99.3	
	140	0.021	0.001	0.019	0.024		92.7	
	200	0.021	0.001	0.019	0.023		87.6	
Total Phosphorus (Annual)	10	0.028	0.004	0.021	0.036	152	100	119
	20	0.028	0.003	0.023	0.033		100	
	50	0.028	0.002	0.025	0.032		99.4	
	20	0.028	0.002	0.025	0.031		98.9	
	140	0.028	0.001	0.026	0.030		91.3	
	200	0.028	0.001	0.027	0.030		82.9	